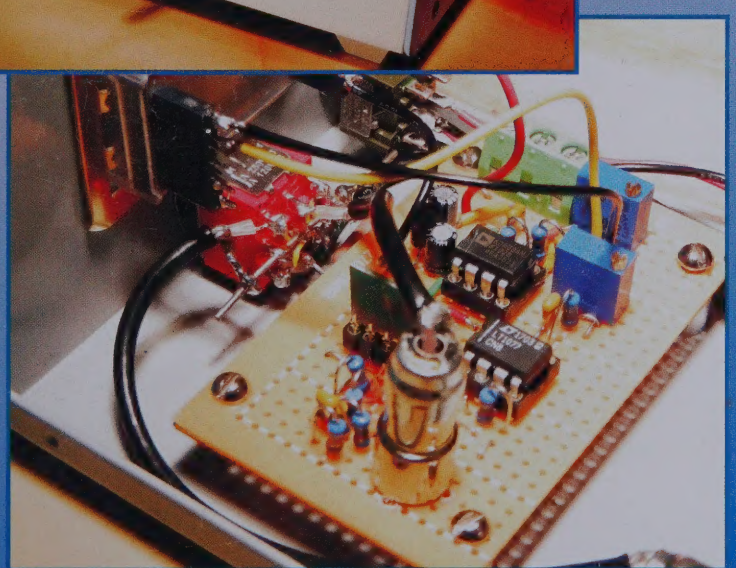
YOUR CONSTRUCTION AND OPERATING QRP SOURCEBOOK

QRP Quarterly

Volume 61 Number 4
October 2020

Journal of the QRP Amateur Radio Club International

K8KK Simplifies the WD9HNU Power/SWR Meter for QRP Power Measurement



- *VE3IPS Gets Ready for His New ICOM 705*
- *JP1QEC's Delta Loop and Matching Network with One Piece of Wire*
- *KB9BVN Lets Us Know About Parks on the Air (POTA) Operation*
- *Reference: K5ATG Lists Amateur Allocations and Allowed Modes*

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Production is underway on the newly redesigned Mountain Topper MTR4b. Similar to the updated MTR3b_LCD, the MTR4b has a full LCD screen and will include 80M in addition to 20M/30M/40M bands. Also, it will include some new features such as a built-in SWR meter! Also, the enclosure is being completely overhauled to be as small and lightweight as possible. ETA by holidays in 2020!

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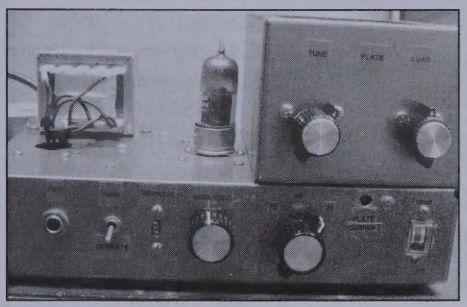

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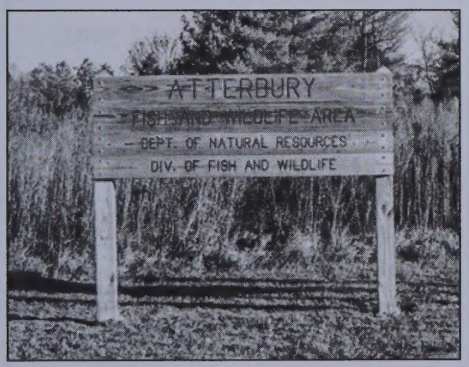

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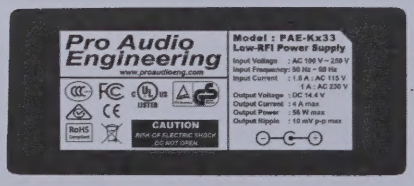

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REMINDER:

QRP ARCI's 2020 Four Days in May (FDIM) was cancelled, like many other events, including the Hamvention®.

FDIM will resume next year, with the usual lineup of excellent QRP speakers and activities!

Some of the presentations scheduled for this year are apearing as articles for *QRP Quarterly*, so you're not missing them!

In the mean time...
Keep yourself safe and well.

See you at FDIM 2021!

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Letter from the Editor

Mike Malone—KD5KXF editor@qrparci.org

Greetings from beautiful Balch Springs, I am delighting in a 65 degree Fahrenheit morning and listening to the sophisticates on the local repeater as I write this. Since we were together last, I am still working at home, cooking at home, staying at home. Some folks doing the same thing are having a bad time of that, and as a hobbyist—I don't understand why they are going nuts. Let's face it, as a radio hobbyist... I would often daydream about being home and playing ham radio.

My typical workday looked like this—take a good beating at work after a grinder of a commute to the office, then further agonizing bouts with traffic to get home. Since I was gone all day I needed to spend time with my family. The evenings found me "stealing" time to play a little radio—whether it was operating, building, or general puttering in the shack. I would have to steal that time from my family, my sleep, or my dinner. When signing off and shutting my station down, it was always with thoughts about that extremely early wakeup so I could get out ahead of traffic and commute back to work. Repeat every day ad nauseum. That was my rut, and frankly, neither my work or my hobby could not exist without the other.

Now fast forward to today. Pandemics are terrible things, but that doesn't mean I have to feel guilty about having an improvement in my quality of life. My days are different... I start work at a decent time and my commute from the shower to my desk (with a stop at the Mr. Coffee) takes me all of 2 minutes. I eat lunch with my XYL and my commute home? You get the idea. At first, I kind of felt like I was playing hooky by getting up early and playing radio, fooling with an antenna at lunch, having a receiver on while doing paperwork. That didn't last long, what I started experiencing then was satisfaction. I am able to spend a lot more time with my family now, and I am finding Shannon is interested in whatever I am getting into in the shack. I moved a chair back there for her and it is our sanctuary. Yes, the pandemic is terrible—but life doesn't have to be bad because of social distancing. I read about folks that go totally berserk, killing their families and themselves. They need a hobby! One thing that has happened with me? I have figured out that my hobbies and passions are as important as my work. Once that mindset changed, I started experiencing a better quality of life.

I hope that you too are finding some peace and satisfaction despite the change going on in our world. Until we are together again, I bid you peace.

72 de KD5KXF
Mike Malone
Editor, QRP Quarterly

From the President

David Cripe—NMØS president@qrparci.org

Greetings to the QRP Community!

It's been a tumultuous few months in many places around the US. Aside from the challenges presented by COVID-19, we have been affected by western forest fires, hurricanes in the gulf, and a devastating derecho wind in the midwest. The latter affected us personally. The Cedar Rapids, Iowa area was affected by winds that were the equivalent of a Category 4 hurricane, leaving 200,000 without power, cell phone, and internet. The community lost half of its trees, and hundreds were left homeless from damage to homes and apartment buildings.

Even before the storm was over, our local amateur radio population was in action. The local repeaters were busy with storm related traffic, passing information where no other communication media were present.

In the NMØS QTH of Mount Vernon Iowa, an local 2M emergency net emerged spontaneously, coordinating gasoline, propane, ice, and generators to where they were needed. Where antennas were deficient, improvised towers were erected so that reliable communication could be maintained.

In the end, most people in the area were without power and internet for a week, and now, a month later, we are slowly recovering.

The value of amateur radio was once again demonstrated by these events. The QRP community shines at times like this. Our emphasis on operating in challenging conditions with often improvised equipment helps develop skills that serve us well in uncomfortable and unfamiliar situations.

Keep communicating, friends.

73, Dave Cripe NMØS
President, QRP ARCI ●●

QRP ARCI News

QRP Frequencies

Refer to the chart on the right for the preferred QRP calling frequencies. You can find fellow QRPers near these frquencies in your daily casual operating. In QRP contests, activity is spread over a wider range, but is generally centered around the calling frequencies.

Band	CW	Phone
160m	1810 kHz *1843 kHz*	1910 kHz
80m	3560 kHz	3985 kHz *3690 kHz*
60m		5346.5 kHz (Ch2)
40m	7030 kHz 7122 kHz	*7090 kHz* 7285 kHz
30m	10106 kHz 10116 kHz	
20m	14060 kHz	14285 kHz
17m	18096 kHz	18130 kHz
15m	21060 kHz	*21285 kHz* 21385 kHz
12m	24906 kHz	24950 kHz
10m	28060 kHz	*28365 kHz* 28385 kHz
6m	50096 kHz	50185 kHz
2m	144060 kHz	144285 kHz

Frequencies in *italics* indicate a preference in Europe.
Digital modes - keep to higher end of usual frequencies.

Toy Store Update

We currently have a limited stock of 2015– 2019 back issues They are $5 ea plus $2 s/h. DX please email for current rates (they have really been going up lately!).

QRP Quarterly on DVD is $28.00 postpaid to US addresses. *QQ* has been the leading QRP magazine since 1961. This DVD contains 59 years of issues, all the articles, and all the projects we've ever published. NO QRP library is complete without it. The latest version includes the latest issue of the *QRP Quarterly*. DX please email for the current shipping rates.

QRP ARCI Coffee Mugs are available for $5 plus S/H.

The Best of Idea Exchange is a great book for all QRPers! It is $25 postpaid in the U.S. DX—contact the Toy Store for current shipping rates, or for other delivery options. See the web site, too!

QRP ARCI Contest Calendar

Three of our most popular contests are right around the corner. Be sure to check out http://qrparci.org/contest for the details!

Fall QSO Party

October 10th—0000Z to 2359Z

A full 24 hour operating period for one of the clubs classic contests.

Top Band Sprint

December 3rd—0000Z to 0300Z

A three hour contest on 160 meters. Put up a vertical or operate with a wire in the park. With a little bit of planning YOU can work a 160m contest with QRP!

Holiday Spirits Sprint

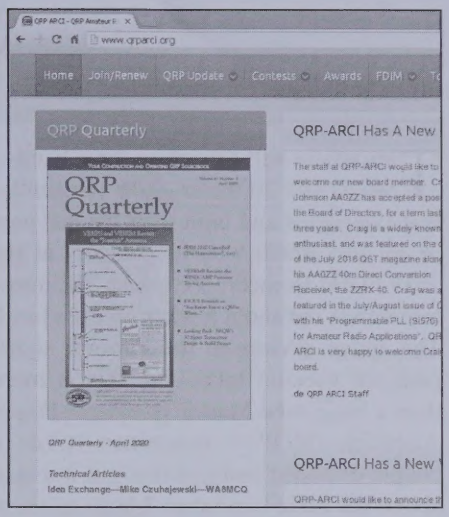
December 13th—2000Z to 2300

A popular short contest which encourages homebrewers to put their rigs on the air. Bonus points for homebrew equipment plus earn extra bonus for those operating from a portable location.

What would you like to see for the 2021 Contest Calendar? Any interest in SSB, digital modes like FT4, FT8, RTTY or others, shorter contests, longer contests? Send in your ideas on contest feedback to contest@qrparci.org

—72/73, Paul K4FB
Contest Manager

●●



www.qrparci.org —check it often!

G-QRP Club Virtual Convention 2020

Dick Pascoe GØBPS, Secretary, G-QRP Club

Following the cancellation of our normal Convention at Telford, during a 'chat' with Nick G4IWO our Chairman Steve GØFUW suggested that we host an on line meeting with G-QRP club members using the internet meeting tool called Zoom. This chat soon developed into a much larger event.

Steve gathered the G Club's committee comprising Graham G3MFJ, Daphne G7ENA and Dick GØBPS to discuss a possible 'Virtual Convention' where various people could present their views to a wider public using Zoom.

It quickly became apparent that this was beyond the ability of our small committee and Nick agreed to take on the roll of manager of the event. Word was put out among our members asking for ideas about should be included and forseeking volunteers who had experience using Zoom. Very quickly Mark MMØDQM, Bill K7WXW and Dave KD3PC stepped in to help. Our usual convention & hamfest takes place on the first weekend in September, so we aimed for this date.

It took a couple of months to get the basics sorted and a Zoom license for a couple of hundred visitors. As the word spread it quickly became obvious that a license for 200 was not going to be enough so we opted for a 500-attendee license. On the Friday morning with over 500 signed in we had to up the license once more. In the end, we had 540 people watching at various times.

The call for people interested in speaking at the event showed that one day wasn't enough so the Sunday was added in too. Club members from all over including several from the USA asked to take part, more on them later.

With a tremble in our voices we met on Zoom just before the start on the Saturday morning. But the event started very well and soon rattled along with little help.

We had a host for each event, mostly someone with experience of using Zoom and an assistant host, Again several from overseas.

First off on Saturday was Hans GØUPL of QRPLabs who entertained us with his background on his kits. Following on was a pair of events with Heather MØHMO discussing Antenna Analysers and Dom M1KTA chatting about organising a QRP DX-pedition.

Next was HF Propagation predictions from Steve GØKYA a well-known author on the subject. After the lunch break on one stream was Mark MMØDQM speaking about his experiments with Mag Loops and milliwatts with Steve GØFUW giving a beginner's guide to QRP.

One of the highlights of the afternoon was Pete Juliano N6QW spreading the word about his homebrew SSB transceivers, another very well received presentation.

The final events of the day were John VE3IPS discussing misunderstood T2FD dipoles and Gil F4WBY sharing his knowledge on QRP SDR radios and operating portable.

Sunday started with Calum MØMCX telling us all about vertical antennas, then Bill G4ERV explaining battery technology and John G8SEQ discussing omni directional antennas.

Another of the highlights was Anthony K8ZT giving a live demonstration of FT8 & FT4. Next came a surprise with a rig in a bread bin. Nick MØNTV explained his totally homebrew radio, constructed in a bread bin. Running alongside this was Les GØNMD showing is inexpensive shack on a pole and discussing the mechanical engineering side of homebrew.

The final presentation of the day was from Alan W2AEW explain about Vector Network Analysers and Nano VNA's, the latest 'must have' tool in the QRP workshop.

This was a very busy weekend,helped enormously by many members behind the scenes, and the presenters on the screens. Without this help the event wouldn't have happened.

Was it worth it? A resounding success by the comments received that made some of us blush!

Will we do it again? Almost certainly. If we are allowed to have a physical Convention in 2021, we will run the online access in parallel with the 'live' event.

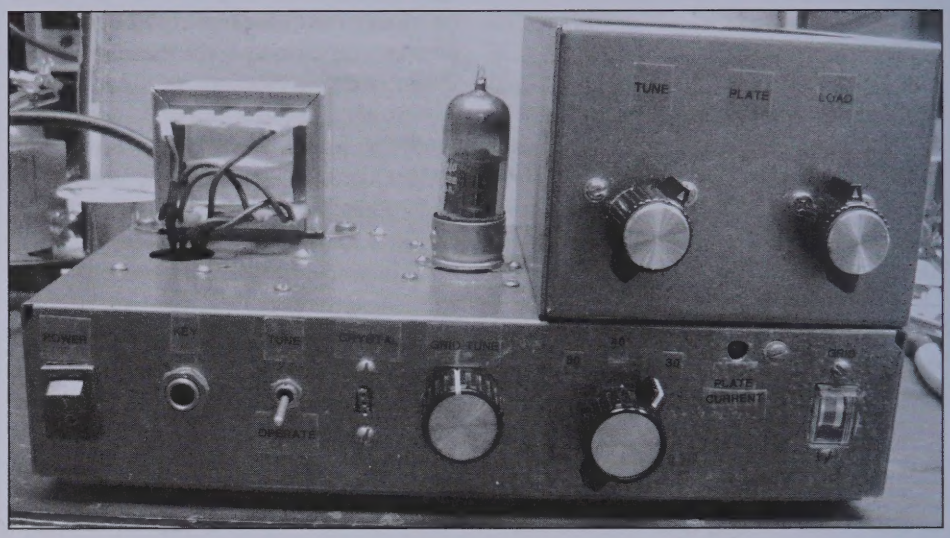
Was it the biggest ever QRP event—ever? Again, almost certainly with over 500 signed in.

●●

A Three Band CW Transmitter

Harold Smith—KE6TI

This article will describe a three band—80, 40 and 30 meter—CW transmitter that I designed and built over the last year or so, and which won its category at the 2019 FDIM Homebrew Contest. The transmitter puts out about 6 watts on each band. The active devices in the transmit signal path are vacuum tubes, but this is more than a basic tube Master Oscillator-Power Amplifier (MOPA) transmitter. It has a couple of added features that put it a step above the basic two tuber. I hope to share not merely the circuit, but the design process, warts and all.



Front view of the transmitter.

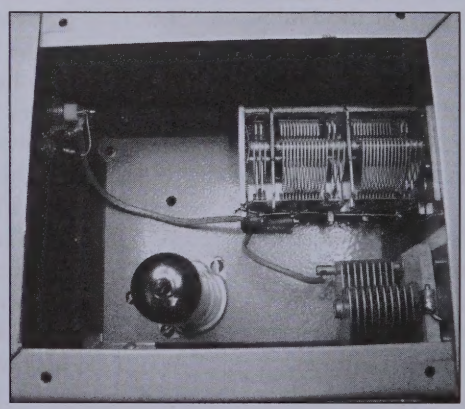
The idea for this first started when I started playing with tubes again, after finding a forgotten cache of them in the basement. For most of my life I made my living as an electrical engineer, designing electronic equipment, but I had never used or even studied tubes. By the time I got to engineering school they were history. But tubes were what ham gear was made of when I first got into ham radio, so I decided I would teach myself.

When I got into ham radio in the sixties, tube transmitters similar to this one were staples of both the commercial and homebrew worlds. There was a crystal oscillator, (Novice licensees in those days were restricted to crystal control.) which was usually a high-g_m pentode such as 6AG7, 6CL6, 6AH6 or 12BY7, and a power amplifier, usually a beam power tube that might be anything from a 6AQ5 to a 6146. Most ran no more than 75 watts input to the final, which was the Novice limit, though a few could be adjusted to run more power after the owner upgraded to General.

I wanted to build a multi-band transmitter, but bandswitching adds complexity. An alternative to a bandswitch was plug-in coils for each band, but that has its own problems. I started designing thinking it would be a three band rig, since I had a multi-section rotary switch in my junkbox that I thought would work. Before I actually got building I found a four-pole, six position ceramic rotary switch in the flea market at a local hamfest for a reasonable price, and decided to try for a six band rig. ...more on this later!

The tube lineup in this transmitter was dictated by a couple of factors. One was that I wanted to stay in the QRP range. I've found that QRP is really pretty effective on CW. I think that's because CW ops tend to listen before they transmit. And the other was simply the tubes that were available to me at minimum expense, which means those that were in my junkbox. I also had in mind that I wanted this transmitter to be used in full break-in mode, which I have gotten used to over the years, and that meant including a T-R switch in the transmitter.

Some circuit details: the oscillator is a Colpitts type, which can be crystal controlled or driven as an amplifier by an external VFO. The active device is the pentode section of a 6CX8, a 9-pin miniature tube, containing a high-gm pentode and a medium-mu triode. The pentode is similar to the venerable 6AG7. The triode became the heart of the T-R switch.



Inside the Power Amplifier's shielded compartment.

The usual Colpitts grid-cathode capacitor may appear to be missing on the schematic, but the few inches of miniature 75 ohm coax that connects the grid to the front panel crystal socket supplies the needed capacitance. The feedback cap, C200, was chosen to give good starting with the minimum of crystal drive, since I don't have any of the old, big crystals that were still common in the sixties. The circuit works fine with modern HC-49 crystal types.

The 3 contact crystal socket is cut from a machined-pin IC socket. An HC49 crystal can be plugged into the two outermost contacts, or a VFO can be plugged into the top two contacts, with the center contact shorted to the bottom one, turning the oscillator stage into a buffer amplifier. Only a few volts drive are needed from the VFO.

The first two poles of the bandswitch are used in the oscillator circuit. One selects the inductor that tunes the plate circuit, and the other selects a combination of resistors that set the oscillator's screen voltage. The screen adjustment turned out to be necessary to keep the oscillator's output relatively constant as the oscillation frequency went up.

I should mention here that I bread-

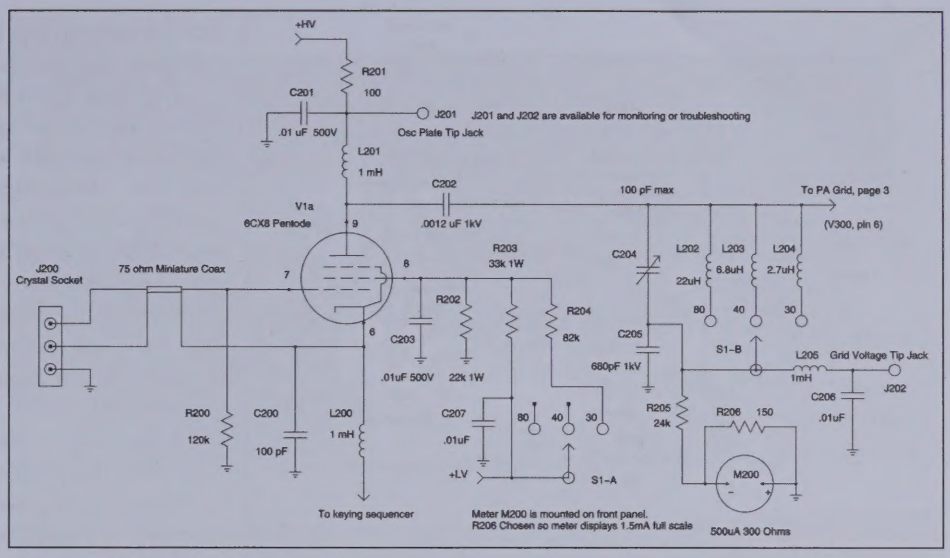
boarded every circuit individually before I started assembling the final version of the transmitter. I didn't want to get finished and discover I had something that simply didn't work. More on this later, as well...

The final amplifier is a 6DB5, a 9-pin miniature beam power tube which is characterized as an audio power amp or a TV vertical deflection amp. With a 10 watt plate dissipation rating it looked to be in the right power range, and I had a couple of them. Also, I had access to curves for this tube, or, more precisely, for its octal equivalent, the 6W6, and the curves included the positive grid voltage range, which I hoped would be useful when designing a class C amplifier with it. Actually designing that class C final turned out to be difficult. I wanted to do the design right, to do the calculations as they would have been done by an engineer actually designing a product. It turned out to be very hard to find any information on how that was done. I have a large collection of technical reference books and textbooks going back to the thirties, and in none of them were there algorithms for class C design. It appears that the writers expected that a designer would simply use the tube manufacturer's suggested operating conditions for a particular tube.

I did have the Eimac book, which includes a plastic chart that can be laid over a tube's constant current curves to design a class C stage, but I didn't have that set of curves for the 6DB5. Eventually I found the design process detailed in an out-of print RSGB book, and that is what I used for this transmitter. Even so, there were a couple of factors that weren't well defined, but I did the best I could, and the amplifier did ultimately work as the calculations predicted.

The output network is the usual PI type. The last two sections of the bandswitch are used in it, one switching additional inductance into the network as the frequency is lowered, and the other used to add additional capacitance at the input of the network on 80 meters.

The T-R switch consists of a cathode follower, the grid of which is connected by a small value capacitor to the plate end of the Pi network. When the transmitter is not keyed, the impedance transformation of the Pi-net feeds a stepped-up antenna voltage to the grid of the triode, which passes it on to the Receiver RF connector. When



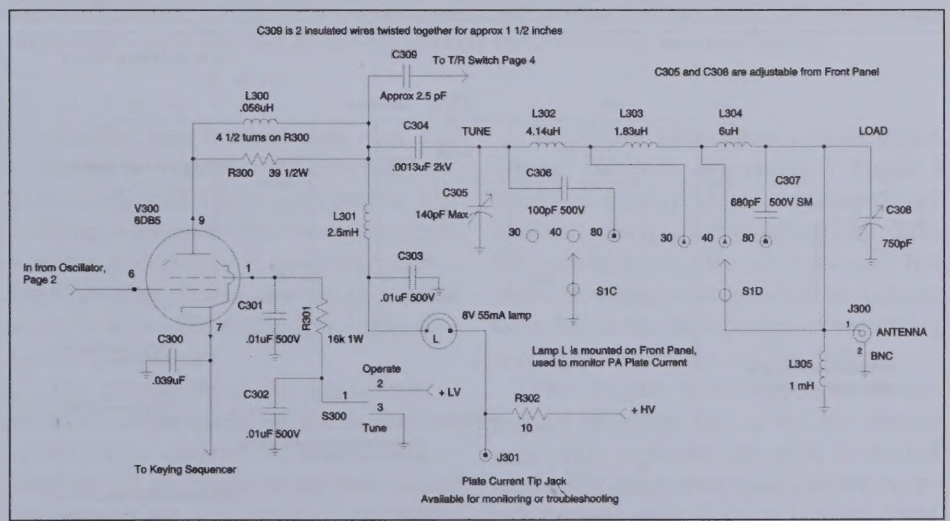
The crystal oscillator circuit.

the transmitter is keyed, the large RF voltage drives the grid of the triode positive, drawing enough current through the grid resistor to bias off the stage, and very little voltage gets through.

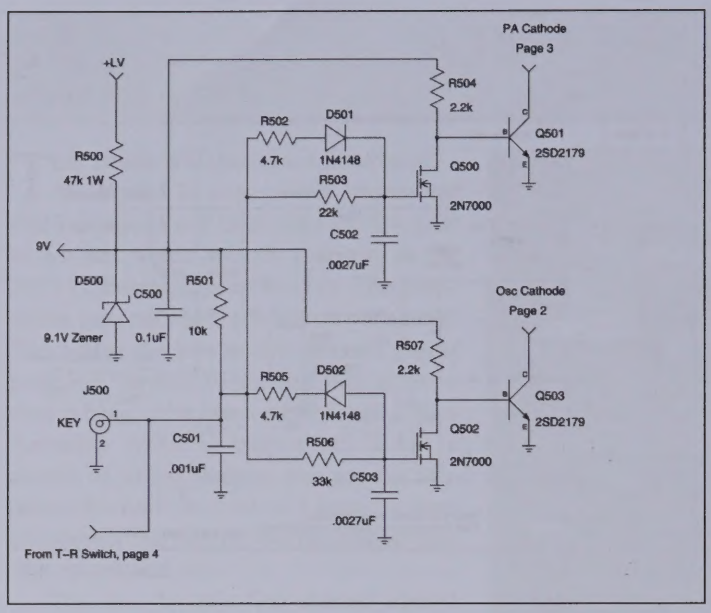
That was the theory, anyway. The key-down voltage at the Receiver RF connector was about 1V peak to peak, which is really too much, especially for a solid state receiver. So I added some additional switched attenuation between the cathode follower's output and the Receiver RF connector. The additional 90 dB (per SPICE simulation) attenuation keeps the receiver's input at a safe level for both receiver front end and listener's ears. The extra circuitry consists of a pair of 1N4007 rectifiers (used as PIN diodes) as series switches, and a pair of 2N7000 MOSFETs as shunt switches.

This transmitter also includes a keying sequencer, to help eliminate chirp on keying. When the key is pressed, a transistor circuit turns on the oscillator first, then the power amp, so that the frequency has stabilized before the signal reaches the antenna. On key up, the reverse happens, with the oscillator staying on slightly longer than the final. The R-C-diode networks at the gates of Q500 and Q502 control the actual timing. The values shown in the schematic seemed to work well.

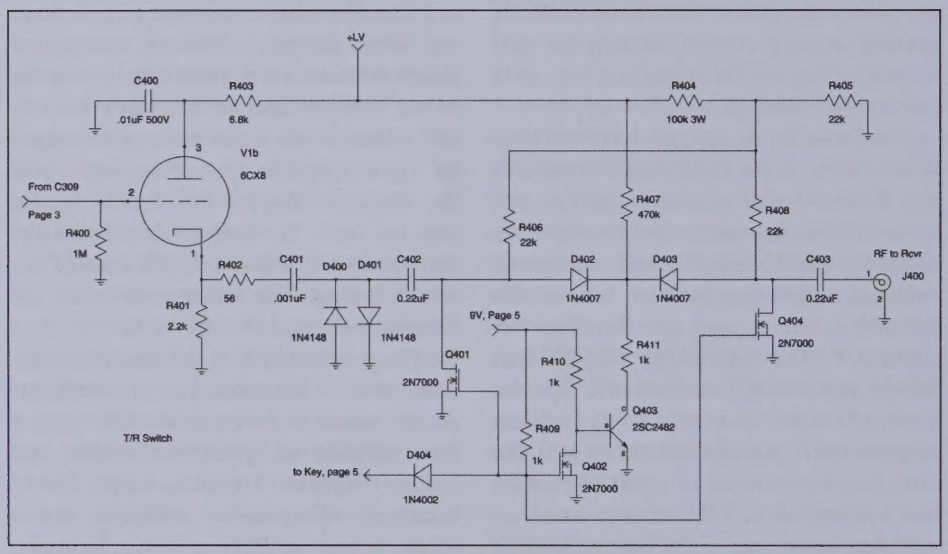
The power supply is included on board. Since the old all-in-one power transformers are scarce and expensive these days, I used separate transformers for plate and filament supplies. The plate supply uses a relatively inexpensive isolation transformer, rated for 120V at 250 mA output. It drives a full-wave voltage doubler recti-



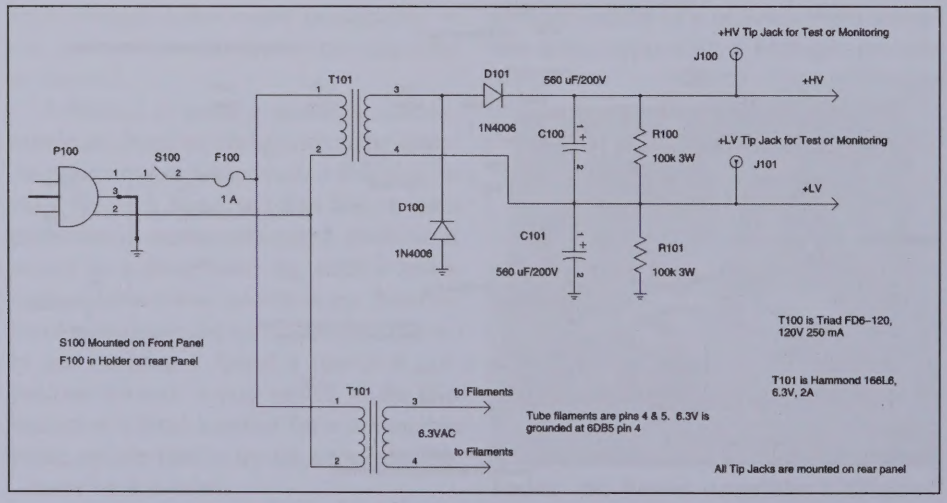
Schematic of the 6BD5 Power Amplifier.



Keying sequencer for the transmitter.



T-R Switch circuit.



Power supply for the vacuum tube transmitter: filaments, 150V and 300V.

fier. Voltages available are approximately 300V for the plates and 150V for the screens and T-R switch.

I tried to avoid building in a meter to measure operation, as meters tend to be expensive, and take up too much panel space. I had what I thought was a clever idea to use LEDs to indicate current flow during tuneup and operation. Though the needed final grid current is only a few hundred microamps, I hoped I could get an indication using a high efficiency LED, one of those that are fully bright at 2 mA. Alas, it didn't work. I ended up using a small surplus FM tuning meter with a full scale range of 500 uA to read grid current. I also messed up the paint making the hole to mount it, which in turn required a repaint make the transmitter look less junk-based.

I also cleverly came up with a circuit that used a regular (about 30 mA full brightness) LED to measure plate current. I ginned up a constant current source that put 25 mA through one LED, while a second, mounted beside it on the front panel, passed half of the plate current. In parallel with that LED was a resistor chosen to pass another 25 mA when the voltage across it matched the LED's 25 mA drop. If that sounds weird, it turned out to be. The dip in plate current was clearly obvious, but the 50 mA maximum was simply not. I ended up replacing that circuit with a small incandescent lamp that is rated for full brightness at 55 mA. At 55 mA the lamp drops 8V, which lowers the plate voltage by that much. If I had had one on hand I would have used a lower voltage bulb in a similar current range, such as a type 331, 48 or 49. I doubt if these are still available new.

To give myself the option of monitoring other aspects of transmitter operation, I included a number of rear panel tip jacks, attached to current sense resistors and power supplies. These were used primarily during setup and testing the transmitter, but are there if needed.

Construction uses mostly tie point strips on a recycled 9.5" x 5" x 2" aluminum chassis, just like all those transmitters from my youth. The chassis was previously used to hold something that involved a lot of holes along one edge. The box that shields the PA circuitry above the chassis was new, obtained as a door prize at a NOGA club meeting. After I drilled what I thought would be all the holes I would need, I sprayed the combined chassis and box with gray hammertone paint, so it would look a bit more professional and a bit more like a rig from my youth. The paint turned out not to adhere extremely well, as mentioned a couple of paragraphs above. I did clean and buff with steel wool before painting, but I probably should have used a primer first.

The solid state parts are built ugly style on pieces of PC stock which are mounted

to the inside chassis walls.

Tuning up this transmitter is basically the same as for any tube-type CW transmitter. The Tune-Operate switch is put in the Tune position, (which removes screen voltage from the final amplifier tube,) a crystal for the desired band is plugged in, the bandswitch is set to that band, and the key is depressed. The grid tuning capacitor is tuned for maximum grid current.

Then the switch is put in the Operate position, the plate loading cap is set to maximum capacitance (plates fully meshed) and the key again depressed. The plate tune cap is tuned for minimum current—the 'dip'—and then the loading cap is advanced until the plate current comes back up to the desired peak. The plate tune/load process is repeated until there is no more dip visible. Maximum output is around six watts on all bands, which is a hair above 'official' QRP levels, but that's what it worked out to be. If one wanted to be strictly QRP, I would suggest using a somewhat larger screen dropping resistor in the final stage.

The title of this article suggests it's about a three band transmitter, but I've been writing about a six band unit. So what gives? Well, there's a bit of a story there, too:

I built the rig for six bands, 80 through 15 meters, skipping 60 meters. I did breadboard the circuits, so it should have worked. Alas, it is a truism in engineering that the difference between theory and practice is that, in theory, there is no difference, but in practice there is.

Once I got the transmitter built I discovered that its behavior was not quite what I had hoped. And troubleshooting was difficult since I had built it into a slightly-too-small package, as I seem to do too often. That, in fact, is one mistake I seen unable to learn from.

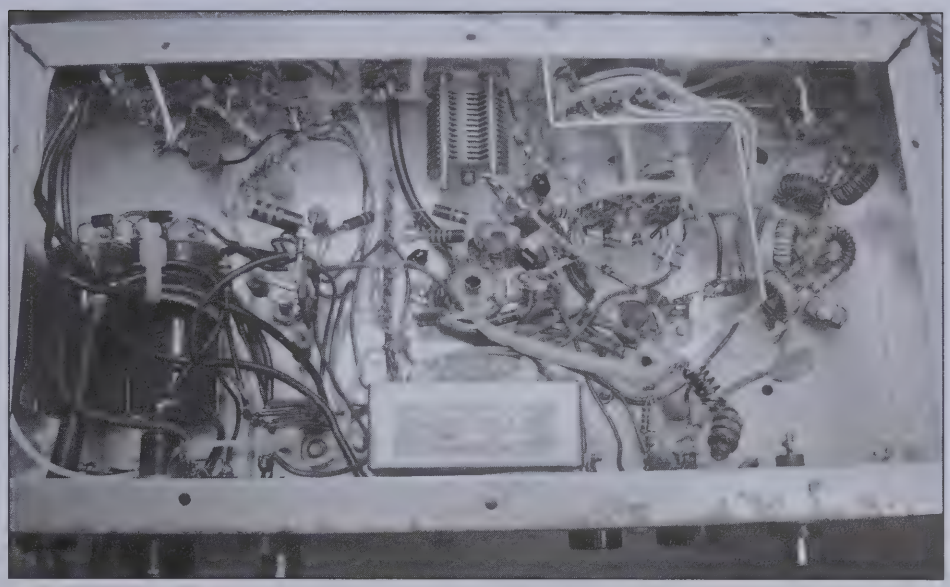
The biggest issue turned out to be an intermittent instability on 20 meters. I probably could have fixed it, but by the time the problem turned up I just wanted to be done building and to put the thing on the air. On 17 meters the transmitter seemed to work fine. And on 15 meters it turned out that the Pi network's input variable cap, the Plate Tune cap, C305, couldn't quite tune to 21 MHz. The minimum available capacitance was just a little too high, probably because of stray wiring capacitance.

I could have included the 17 meter band, since that worked okay, but that would have meant either rewiring the bandswitch or leaving a gap between 30m and 17m. And since I don't have any crystals that are actually in the 17m band—I tested it using crystals that are just below and a bit above the band edges—I decided I could live without.

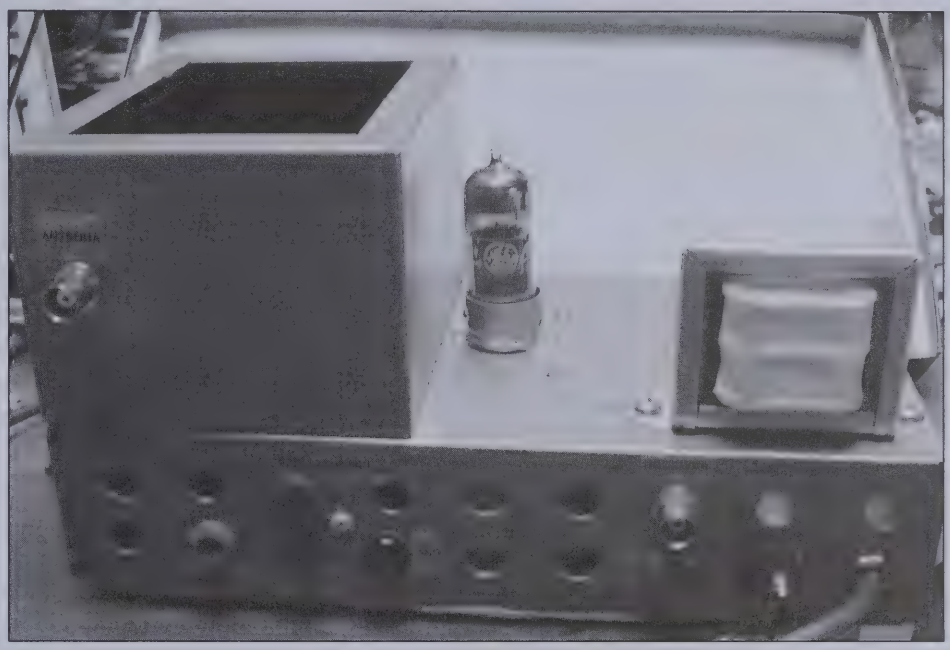
The photos show the transmitter as wired for all six bands, but the bandswitch is labeled for only 80, 40 and 30. Maybe someday I'll dig in and fix the band issues, but probably not. I'm actually pretty happy with it as it is.

This is not intended as a construction article. As with everything I build, I depended heavily on the vagaries of my junkbox, and I'd bet anything that there isn't another just like it anywhere. But maybe somebody out there will be inspired to try his or her own design, of something similar, or something entirely different.

The biggest advantage of a home-brewed radio like this is that the builder only has to make the one work. It doesn't need to be production ready, either in circuit elegance or economy or in appearance. Try it. It's fun! ●●



Underside of the chassis. Old timers will find this quite familiar!



Rear view—note the test probe tip sockets used for setup measurements.

A Nice Multimeter: the Aneng AN8008

Jim Stafford—W4QO jim@w4qo.com

I've been a fan of test equipment for a long time, a real long time. I remember modifying my Heathkit V7 VTVM to use in my high school science fair when I built an Inexpensive Automatic Titrator with it as a key component. The one at right is almost $3000. Perhaps I should have gotten a patent!

But I digress. I have several VOMs but was watching a YouTube video (learn electronics series) on the Aneng AN8008 and heard that is currently very popular. Well, I ordered one and at less than $20, it looked like a good value. I bought mine from Banggood on sale for less than $16 so be patient until it goes on sale if you care. Go to Banggood.com for a full set of specs. I was pretty cautious about ordering on credit card with Banggood the first time but it has been absolutely a breeze for a couple years.

Let's look at some of the features that you might not expect from a VOM like those you can get for free from Harbor Freight. First, it is a true RMS meter and is a full 4 digit unit. In other words, it can read to 9.999. Not 3-1/2 digit as many older ones are. Also, it has a square wave generator to 5 kHz. Nice to inject a signal for tracing in radio or audio equipment. It has a counter which measures to 10 MHz as well as a pulse width modulation duty cycle measurement. It comes with 2 sets of test leads—one for "high" voltage of say house voltage and one that has interchangeable tips. It is spec'd to go much higher. Just be careful for those 600 volt circuits!

It will measure AC/DC current up to 10A and down to 0.1 µA. It will measure capacitance from 1 pF up to almost 1 Farad. It is an autoranging VOM. It doesn't take too long to find the range except in capacitance which is understandable for larger capacitors which have to charge up. It can be forced into manual ranges if needed (or desired). It is not a large unit, rather it is a handheld size. It comes in a variety of colors with a back light and auto OFF feature. It has a back stand (kick stand) which makes it handy for bench use. As it is very light weight, try not to pull it off the bench, however. Oh, it has a 4.999 rating with almost 2000 reviews!

I have put it through accuracy measurements and it seems to be right on specs which is about 1% for most measurements. Oh, it does not measure transistors. However, it seems to be a general feeling that transistor measurements are put on a meter to impress folks but is of little use. This one does a nice job of measuring diodes however. They actually light up and it reads the forward voltage value which is nice. All in all, I've found this unit very handy.

So do you need another multimeter? Probably not but for the price and features, it sure is "handy".

●●

It's not too soon to plan for FDIM 2021! Keep an eye on the QRP ARCI web site for information:

www.qrparci.org/fdim

Getting Ready for the ICOM 705

John Leonardelli—VE3IPS ve3ips@gmail.com

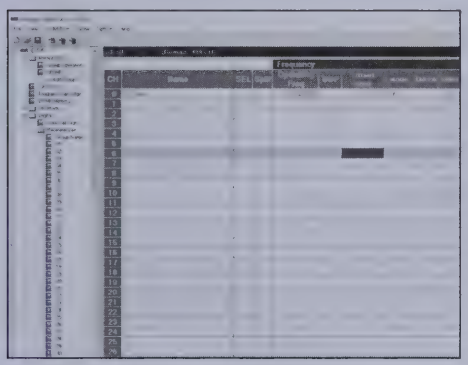
Icom 705 Delivery: September 2020

I am expecting my ICOM 705 in September and I have been busy getting everything ready so no time is wasted getting on the air. Bear in mind that after reading this, I am not responsible for any withdrawals from your bank account or your credit score ratings being affected. Here is a list of things to consider to make the radio and operation more enjoyable:

Programming Software

Download the CS-705 software to build out your memories in advance.

https://www.icomjapan.com/lineup/options/CS-705/



RS-BA1—IP Remote Control Software that will allow a user to remote their radio in a base location and then use the internet from a hotel for example to operate the radio.

Antenna Tripod

I plant to use my utility tripod to hold the various antennas when picnic table operating using the Super Antenna mount. It will be a mix of BNC antennas, 3/8 in. stud mount and even PL-259 or M based. I will not be using the ball head as I will be using it with the Super Antenna mount.

The radio needs to have some thick rubber feet or a way to get it off the table to be able to use the VFO knob. The Manfrotto Pixie Mini tripod makes it easy for using the radio at a comfortable height.

Icom Battery

I have 3 of these BP-272 battery packs already and the LC-192 backpack has 3 slots to hold them. I understand based on current tests that at 5W the battery life will be similar to the test on the ID-51A handheld.

BC-202 Quick Charger

The Icom BC-202 rapid charger is designed to charge the BP-272 Li-ion batteries for the ID-51A. The BC-202 comes with the AC adapter as shown above. The BP-272 takes approximately 3-1/2 hours to charge.

Manfrotto Table Top Tripod Kit **Super Antenna UM2 mount** **Manfrotto Pixie Mini**

ST-4001A/ST-4001I

Smartphone Picture Utility Software will allow pics to be sent back and forth using D-Star

RS-MS1A

The RS-MS1A is an application that allows your Android device to remotely use some of the D-STAR and DV mode functions of the 705. Download from the Google Play Store

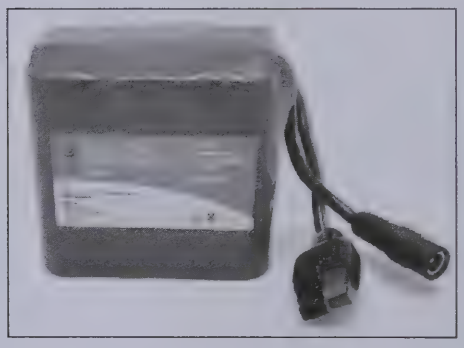
RS-MS3A

The RS-MS3A is an Android device application designed to expand the DV mode capability of a D-STAR transceiver using a Terminal or an Access Point mode.

These modes enable D-STAR operations by sending signals from the D-STAR transceiver over the Internet, even when that transceiver is out of range of a D-STAR repeater. The transceiver sends your voice signals using an Internet, 3G, or LTE network, through an Android device. Download from the Google Play Store

External Battery for 10 watts output

Buying 3 BP-272 will be more expensive and if you dont need the high portability then just get a proper external battery. This is lighter than an SLA. I have the Bioenno 12V, 4.5Ah LFP Battery (PVC, BLF-12045W). You need to buy the charger that is sold separately



Patch Cords

The antenna jack is a BNC so you will need various patch cords to connect to various antennas:

- BNC to SO-239 to connect to a longer RG8x cable
- BNC to PL-259 to connect to my CRM mount or Super Antenna mount or to the LDG tuner
- BNC to N connector to connect to M2 440 MHz and Arrow satellite yagi
- BNC to BNC Patch Cord for interconnects to the T1 antenna tuner

Coax Cable

I have several 25 and 50 ft Buddipole cables. They are MILSPEC and have covers for the connectors. It's BNC, so you'll need some adapters.

Topo Design Camera Cube

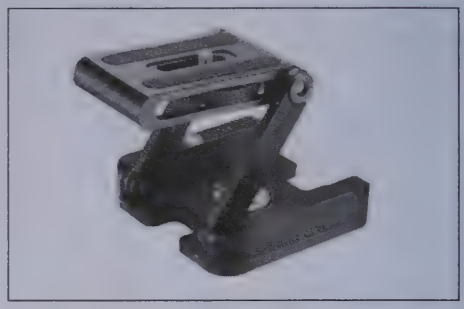
I needed an optional case for the radio and the Topo will be useful. The padded divider board can be used to cover the screen. My idea is to have a shoulder carry bag in place of a back pack for some field operations like at a Krogers Aisle. My ICOM 705 mock up fits perfect. Photo is at the top of the next page.

Ammo Box Go Box

I added a shelf to my ammo box for the KX3 and the form factor is similar for the 705. I will add a rubber plate to get the radio up off the shelf a few inches or may use the Manfrotto ball mount. Use of my mock up was very useful and was also used in my prayer room to help ICOM get manufacturing going. (Prayers were answered).There is room inside to house a bunch of things like a tuner, battery. I have various antenna ports on it as well. A BNC to BNC patch cord will work but I will relocate the BNC jack to the other side.

Z-FLEX Mount

I am looking at using the camera mount as an option to mount the radio to other things like a clip board, table, mobile mount bracket arm.



The advantage is this may be more stable than a ball head and will need some experimentation

BNC Right Angle adapter

To mount a BNC dual band rubber duck properly. I have the one from Icom 32AT I will use but the Smiley us tuned for 440 MHz not 430 MHz like the Japanese versions

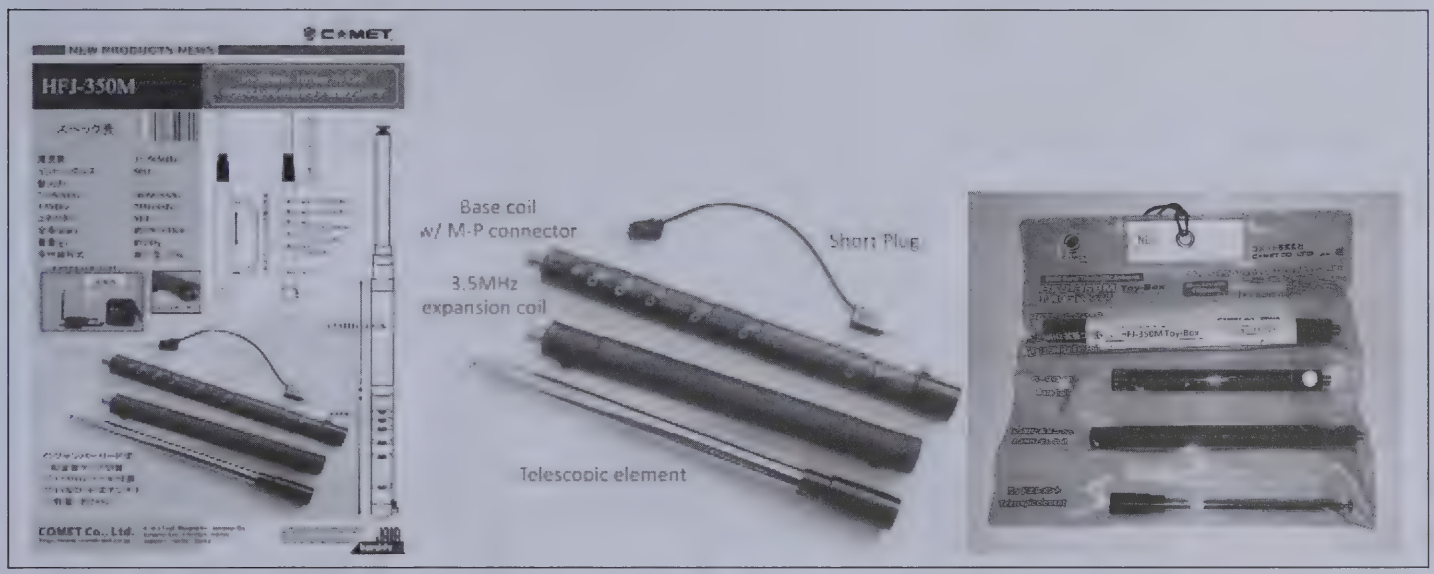
Smiley Antenna

TRI BAND 2 M / 220 / 440 flexible base loaded telescopic antenna is the standard for field use whether in the countryside or city. This super efficient VHF/UHF antenna provides a OMNI directional 3 to 9 dB gain depending on position and is usable in 4 positions: 1/4 wave 2 Meter Fully extended; 5/8 wave 440 2 sections down; 1/4 wave 440 fully collapsed; 1/4 wave 220 4 sections down.

Has a tuned coil/spring. This flex coil matching network provides at band center low SWR as well as a ±5 MHz band center. Antenna tuned at 440 MHz being the band center, the antenna will perform the same between 435-445 MHz. Length tele-

The LC-192 backpack.

ICOM LC-192 Back Pack—At $150 USD it's expensive but this is needed to go play out and about with the 705. The key feature is the top shelf with a 1/4" bolt to hold the radio in place and a side plate that will hold the Diamond MCR grip or the CRM plate for an external antenna. Its not a big pack but will be great for short jaunts and summits.



HFJ-350M Antenna—If you are Japanese then this is the antenna everyone in JA land is buying. MFJ has the 1899 and there is the ATX version. I made my own and am debating if I will buy this but our local store now stocks it. The Toy Shop version adds a 160m coil which is a new band for the JAs.

scope is 4.5 in. down and 16.5 in. up.

www.smileyantenna.com/
product-p/27000.htm

I have a 1/2 wave 2M Antenna that I will use as well

MFJ-18XX Single Band Whips/Elecraft AX-1

These special single banders were designed specifically for the extremely popular Yaesu FT-817, ICOM 705 and Elecraft KX3/KX2/KX1 Multimode HF/VHF/UHF Portable Transceivers.

These single band, base loaded telescopic whips are fitted with a BNC connector and handle 25 watts. Each whip telescopes from around 26 cm to approximately 1.4 m.

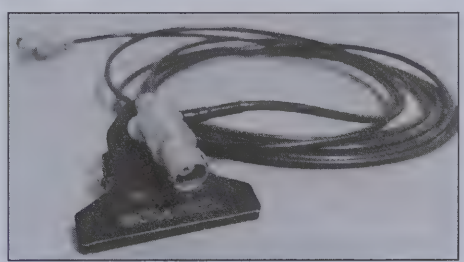
I have one for 40m, 20m, 17m and 6m and they work well with a counterpoise. (You need the CP).

You can also add the California DXers special and go with the super nice AX-1

Diamond MCR ii Antenna Clip

I have something very similar to the one in the photo that I bought in Japan. It is not a Diamond brand but it's identical.

I made one with an office Bull Clip as well. Just need some Epoxy glue.



Dipole

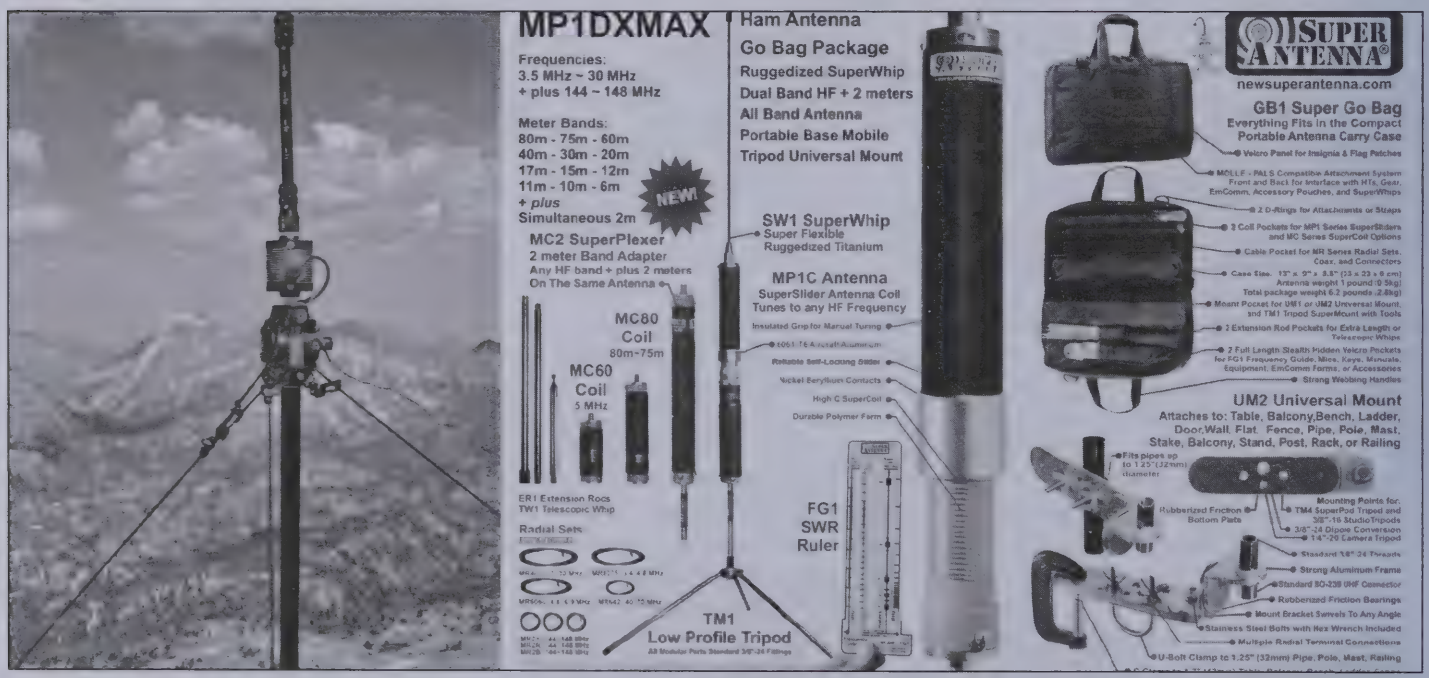
Stop crying about the antenna tuner already and make better contacts with a dipole cut to the bands you want. I usually work 40m and 20m so I use a PackTenna Linked Dipole. I have made hundreds of contacts with it. I have switches that add

the length to resonate on 40m. Try this as well:

https://ve3ips.wordpress.com/2019/04/02/packtenna-in-the-field-linked-dipoles/#:~:text=Dipoles%20are%20quick%20to%20set,single%20wire%20antenna%20is%20perfect

I worked NJ2US with 2 watts in the winter cold with it when I was testing it out.

RH-770 Antenna BNC—If you area fan of Masaco then this is the antenna everyone in JA land is buying; The RH-770 Diamond 2m/70cm Telescopic It's an ideal antenna where DX performance is required. It covers 144 and 430 MHz and unscrews into 2 sections.



Short Format Antennas—

Buddistick Antenna.

I went with the Short coil for 20m and up coverage as I am never happy with these things on 40m and just go dipole or a long wire. I also have the 8 ft mast that I made adapters for to be used with other stuff.

SuperAntenna MP-1

Don't forget the rest of the accessories like the spike, UM2 mount etc. I find the TM1 tripod too flimsy and have substituted a proper Manfrotto Camera tripod. The 190 works wonders

Pac-12 Antenna

My home brew version works wonders and I have now made coils that use the 1/4 inch bolt in place of the 3/8 bolt. This is an excellent antenna. Buy or build.

http://www.golborne.com/ham/pac12/

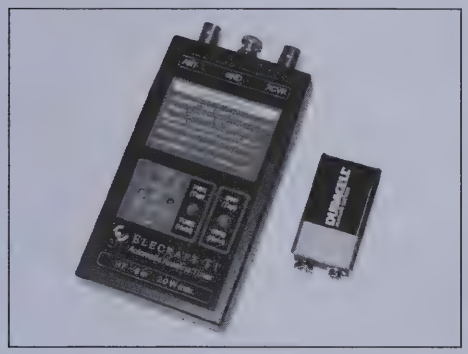
https://www.qrpkits.com/pac12.html

https://ve3ips.wordpress.com/2018/01/15/packtenna-mini-11-balun-arctic-field-test/

Or you can go with an end fed for 20m and have flat SWR.

Elecraft T1 Tuner

Use with any low-power transceiver. The T1 can be used with any 0.5-W to 20-W transceiver covering bands in the 160-6m range. Push the tune button and go. Matches 2 shopping carts at Walmart without a hitch.

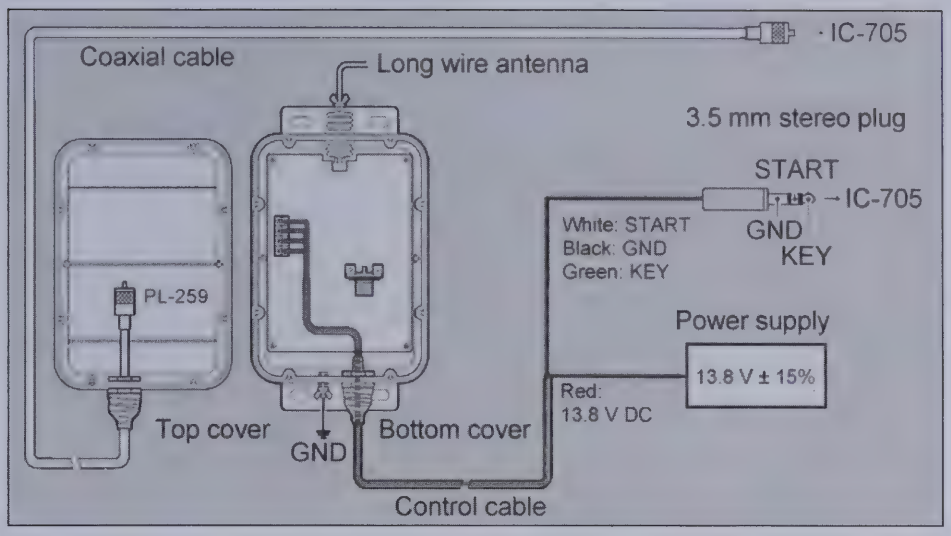


LDG Z817 Tuner or Z11

Want an East Coast version of a Tuner then this one will work for you. Just hit Tune and off you go. Matches the crutches antenna with a 4:1 balun. I have both but will probably just use the Z817

ICOM AH-705

Expected to be released later this year and will have latching relays for power consumption efficiency. Runs on internal batteries or 13.8v.



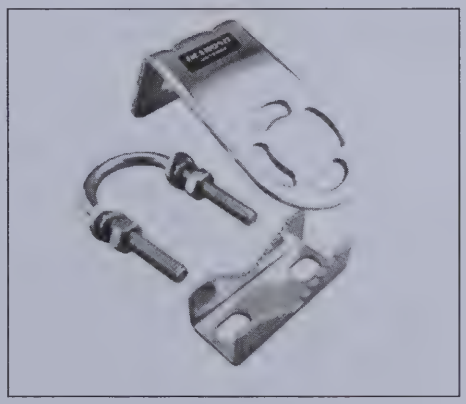
ICOM AH-4 OverKill Antenna Tuner—If you are maritime mobile then I get it. I made the adapter cable for it and will try it with mine. https://www.fbnews.jp/202007/ww02/

mAT-705

Need a tuner from China? Purpose built for the 705 with an integrated control cable.

Diamond CRM Bracket

Mounts right on the side of the LC-192 backpack and yes, you don't need the U bolt...



ICOM VS-3 Bluetooth dongle

The ICOM VS-3 Bluetooth Headset enables you to have hands-free operation with a Bluetooth enabled transceiver. The VS-3 has an internal lithium polymer battery, PTT switch, 3.5mm earphone jack, external microphone, VOX capabilities (when transceiver's VOX function is enabled) and USB port for charging.PTT in your hand with the radio snug in the back pack.

Alpha Antennas AL-7045 mag Loop

I was never happy with these antennas on 40m due to their less than 10 percent efficiency rating. They do work better on 20m and up but then I would rather use the whips for easier use. At $400 USD they are very expensive and touchy to tune. You will walk back and forth many times to get it right and but then the station you wanted to work went QRT.

AlexLoop

I have been very pleased with the Alex Loop as its build quality is the best and its light weight makes it easy to carry around.The AlexLoop WalkHam Portable

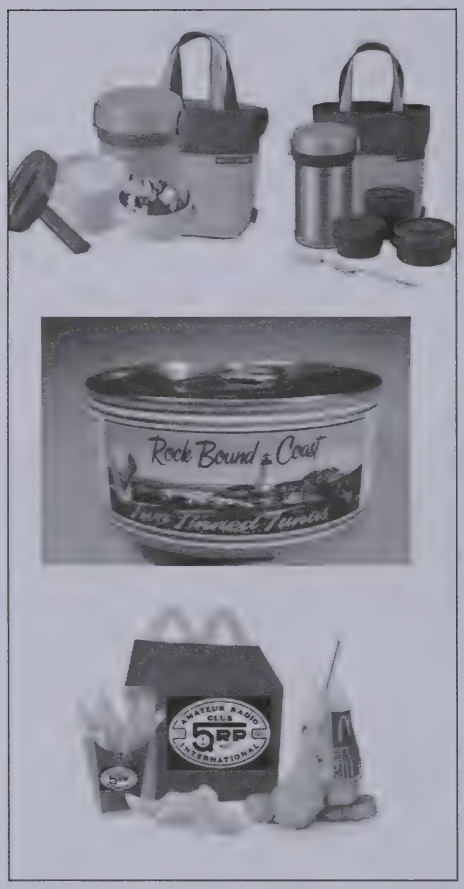
Loop Antenna is the antenna of choice for Phil Salas, AD5X

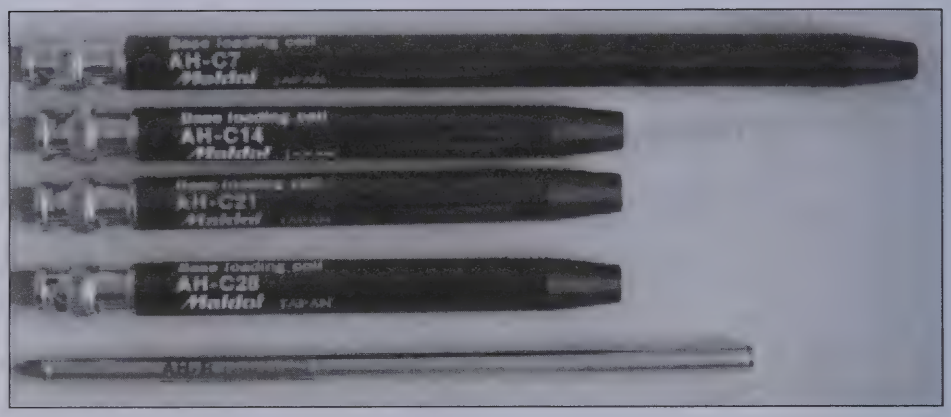
12V Power Supply

Kx33 Low-RFI AC Power Supply for HF Transceivers. I am very happy with this PSU. No noise and light weight

Zojirushi Mr Bento

If you are packing a meal up to the summit then your Ramen and Sushi will stay fresh here. I have packed a QRP meal in here as well. Tuna is also a great QRP food item.





MALDOL Whips

I have been happy with this antenna system, but it does need a counterpoise wire for it to work. https://ve3ips.wordpress.com/2017/06/08/maldol-ah-7-ah-21-ah-28-ah-c-14-qrp-whip-antennas/

These are what I call a shirt pocket antenna and would be ideal in a Topo camera cube with a line winder of #26 stealth wire from DX Engineering.

ICOM 705 Rice Crackers and Lantern

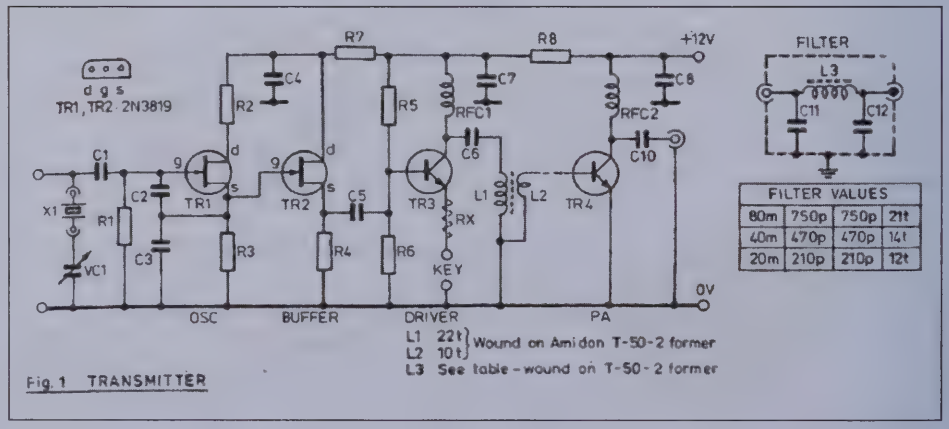
GQRP SCD Transmitter Schematic

Our friends in the UK have a version of the Tuna Tin transmitter. Check the SPRAT website for the pdf.

http://www.gqrp.com/scd.pdf

An updated circuit by W6EMD is shown at the bottom of the next page. It's also available at:

http://www.qrpme.com/docs/TT2%20Schematic.jpg



Beginner's Zeal

Don Goetz—WBØISG

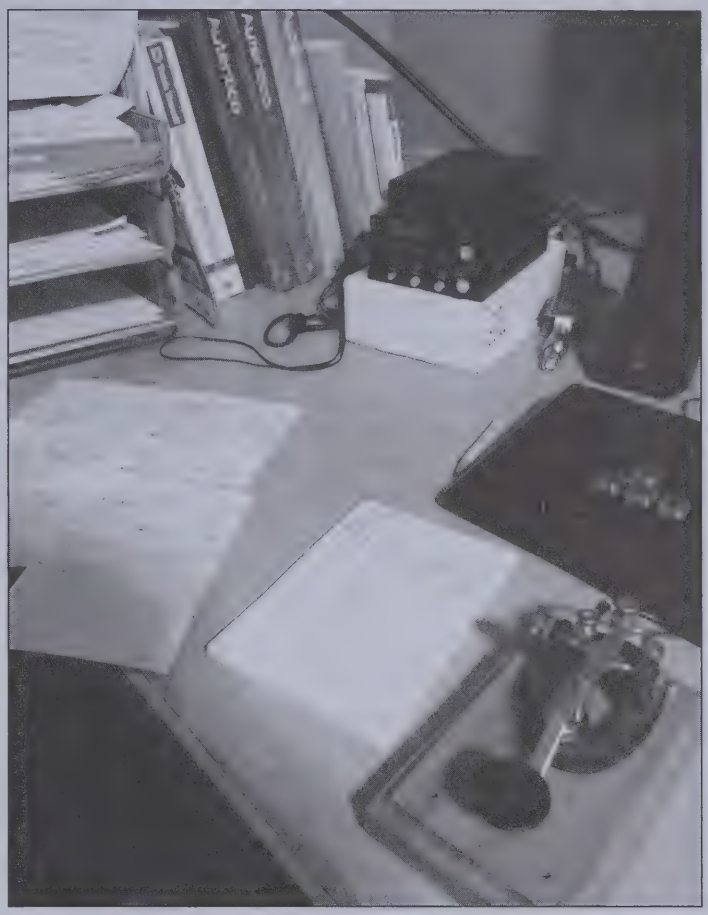
By most standards, I haven't been a ham for long. In the four years that I've had a license, I haven't been too terribly active either. Sure, I'd check into the 2m repeater nets, but not much beyond that. Being a young professional working long hours then going home to a rented QTH puts serious constraints on RF output.

Things have changed. I purchased a house on a half acre lot back in March, upon which there is room for a full dipole on 40m. It isn't too much of an embellishment to say that the radio room was the first room of the house to be fully unpacked. Once I had that antenna installed in the backyard—along with the obligatory 2m vertical—I began learning code in earnest and started racking up SKCC contacts shortly thereafter.

Now that I have some eighty CW contacts logged, I can have some basic conversations about rigs, antennas, and whatever else comes to mind. The goal of making centurion is almost made and I've set my sights on having a QSO a day for at least a month, all at QRP. New goals have been set, but more importantly, new friends have been made. It has been wonderful to run into those operators whom I struggled to copy just a few months ago, exchanging not only calls, RSTs, and QTHs, but also having full blown conversations. Slow and basic conversations, yes, but conversations nonetheless.

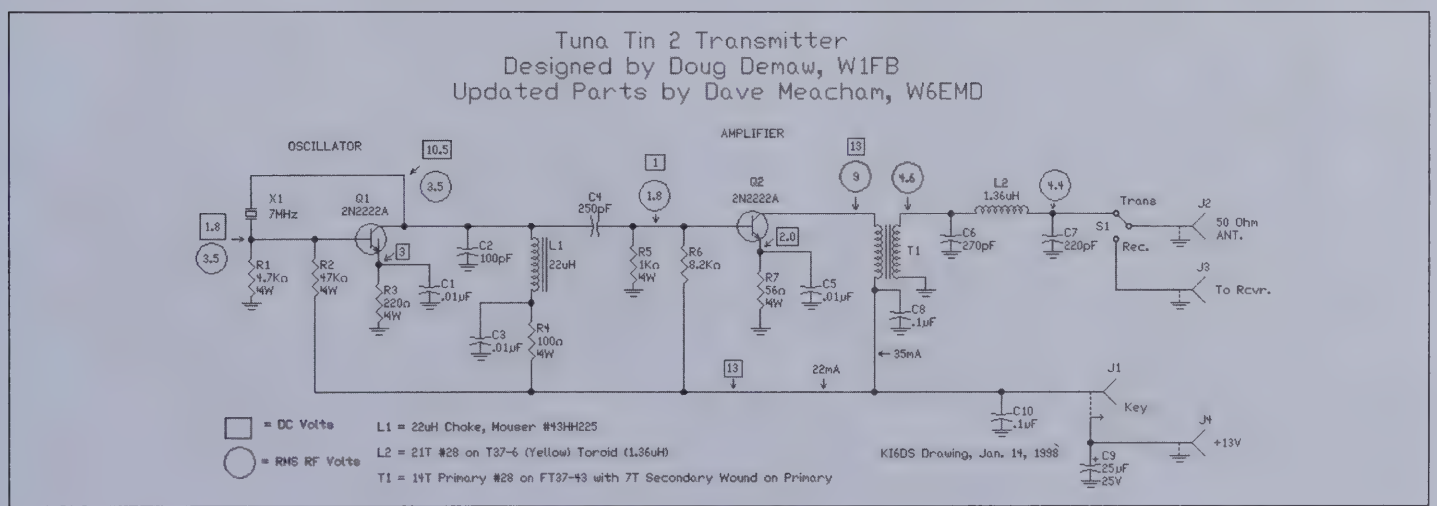
The same things that appealed to me about QRP operation four years ago still do now: the thrill of building one's own equipment, the satisfaction of having scratched out a QSO from so little power on both ends, or even of just having been received with so little output. Not to mention the money saved. I am but a lowly student of the humanities; my technical knowledge is limited, but growing. However, I can paint by numbers to get a working radio and I can follow a recipe to get a working antenna with the best of 'em.

There have been many who told me throughout my short ham career that QRP is not suitable for beginners. Perhaps I'm being foolhardy here, but I don't think this is the case. In fact, I'm becoming increasingly convinced that this advice scares away many potential operators. Too much emphasis is placed on getting



on sideband with a 100W rig. Under the advice of elmers, I went that route and got on the air when and where I could, going out for POTA activations on phone. I didn't find it all that interesting. Too heavy. Too rote. Too nerve wracking. The QRP siren song kept luring me in, just as it had since I first got my ticket. I'm glad that I finally caved in, built a kit, and saw just what five watts can do.

All that being said, perhaps all this is written with the zeal that only the newly converted can possess. ●●



Z-Match Tuner Efficiency

Mark Meyer—WUØL meyerfin@hotmail.com

During the Covid-19 forced boredom period I was messing around in the garage contemplating cleaning the place up. Digging around in a box of old discarded circuit boards and associated riffraff from old projects, I came across a metal box that had a one-time been an antenna tuner. It had been a T-Match tuner that did not use the traditional tapped inductor but used a whole series of small inductors switched in and out with mini toggle switches. It worked fine but I soon discovered that the mini toggle switches were not compatible with very much rf current and soon began to fail. The box still had the variable capacitors mounted on a plastic board insulated from the metal box. "Ah ha", I thought, "a great start for a Z-Match Tuner." This sounded much more interesting than cleaning the place up.

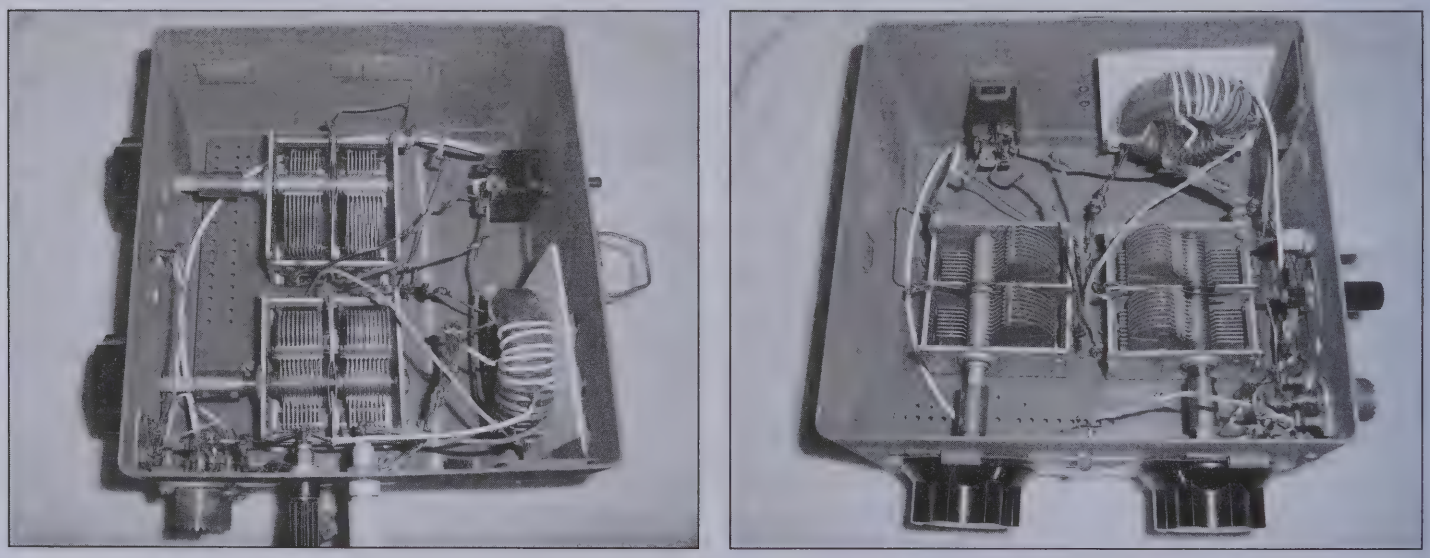
WUØL's Z-Match Tuner.

Internet searches uncovered a wealth of information on Z-Match tuners. Little ones, big ones, powered iron toroid inductors, air wound inductors and etc. All basically the same simple circuit. So I was off and running to build a Z-Match. This would be my second Z-Match as I had already built one but it resides at my winter home in Texas. And I loved the way it works.

The box was aluminum and the original purpose was housing a military device. The only access to the box was down through the top, but despite this clumsy condition I got the Z-Match built and working. It is nothing unique—two dual variable capacitors of 350 pF each section and a T200-2 toroid. The toroid was wound with 25 turns of 18 gauge magnet wire for the primary. The taps are at 10 for the resonating capacitor and 15 for the transmitter input. I had the T200-2 on hand but the T200-6 might be a little better for the higher bands. The secondary was 11 turns of insulated 18 gauge wire with a tap at 7 turns for the low impedance output and the full winding for the high impedance output. I also built in a PA7MAA tuning indicator. This works well but only gets you roughly tuned. An SWR meter is required for fine tuning. My home brew rigs always included a SWR meter built in for that purpose.

The tuner works fine. Tuning is very precise and the dip in the SWR meter is very steep for some tuning conditions. It is possible to tune right through it if not being careful.

Then I began thinking about efficiency. I have read in several articles that Z-Match tuners are very efficient but I saw no test-



Side and front views of the inside of the tuner, showing the circuit layout.

Frequency	Loss in dB	Loss in %	Efficiency in %
3.5 MHz	0.33	7.4	92.6
7 MHz	0.70	14.9	85.1
14 MHz	.67	14.3	85.7
21 MHz	.67	14.3	85.7
28 MHz	0.49	10.7	89.3

Table 1—Loss measurements using the AI1H method.

Load	7 MHz Lo Z	7 MHz Hi-Z	14 MHz Lo-Z	14 MHz Hi-Z
18 ohms	86%	86%	90%	90%
400 ohms	88%	86%	78%	93%
800 ohms	73%	94%	88%	99%
1800 ohms	30%	70%	34%	70%

Table 2—Loss measurements with the oscilloscope and different load resistors.

ing evidence that showed this to be true. I recalled that years ago there was an article in *QST* where a ham tested several tuners to actually get some hard numbers on efficiency. Going to the ARRL *QST* archives, I found the two part article in the April and May 1995 issues. Frank Witt, AI1H, tested several types of tuners and some of the results are rather disconcerting. Us QRPers really don't want a good portion of our 5 watts being dissipated as heat in a tuner. Then an internet search turned up a mid-1990s article by Lloyd Butler, VK5BR, who tested several Z-Match tuners for efficiency. His tests reveal that some units were very efficient, some not so good. I decided to try testing my tuner.

I used the exact same procedure that AI1H described in his article. An MFJ 259 provided the RF signal and the SWR measurement. The various resistors where carbon film measured as close as I could find to the required value. Table 1 provides a summary of the results.

I found very little difference in loss if I used the Low-Z output tap or the Hi-Z output tap.

I have an accurate 50 ohm dummy load so with my oscilloscope I measured the output of my rig at both 7 MHz and 14 MHz without the tuner in-line. Then with the Z-Match in-line and properly tuned up feeding non-inductive resistors, I measured the power into various resistors. The Table 2 contains my results for these tests.

My conclusion is that my Z-Match is quite efficient but definitely has some limitations, especially with high Z loads as evidenced in Table 2. I have read that if a match can be obtained with both the low and high impedance taps, use the high tap for better efficiency. Table 2 bears this out but my testing for Table 1 didn't not reveal any significant difference. The results also suggest that adding more turns to the secondary of the Z-match may be of help with high impedance loads or that a 4/1 or 9/1 balun might be needed to feed the antenna.

I hope this bit on information is of interest to by fellow Z-Match users.

—Mark L Meyer, WUØL

Upcoming QRP ARCI Contests

Fall QSO Party
October 10th—0000Z to 2359Z
A full 24 hour operating period for one of the club's classic contests.

Top Band Sprint
December 3rd—0000Z to 0300Z
A three hour contest on 160 meters. Put up a vertical or operate with a wire in the park. With a little bit of planning YOU can work a 160m contest with QRP!

Holiday Spirits Sprint
December 13th—2000Z to 2300
A popular short contest which encourages homebrewers to put their rigs on the air. Bonus points for homebrew equipment plus earn extra bonus for those operating from a portable location.

Parks on the Air: QRP Style!

Brian Murrey—KB9BVN brian.murrey@gmail.com

Note: https://parksontheair.com

Parks On The Air, or POTA as most of us know it, was inspired by the outstanding work of Sean Kutzko (KX9X) and Norm Fusaro (W3IZ) from the American Radio Relay League (ARRL) in 2016.

When working within the POTA program you are one of two types of stations. The first type is as a Hunter. The Hunter typically works from the home station and tries to contact as many park Activators as they can. The Activator is the second type of station within the POTA system. The Activator is an operator that takes his gear to the park location and starts calling CQ POTA. That's it in a nutshell.

ATTERBURY
FISH AND WILDLIFE AREA
DEPT. OF NATURAL RESOURCES
DIV. OF FISH AND WILDLIFE
Fish & Wildlife
Management Area
Paid for by hunters, anglers and trappers
For all wildlife to thrive and all people to enjoy

My June 2020 POTA Activation location.

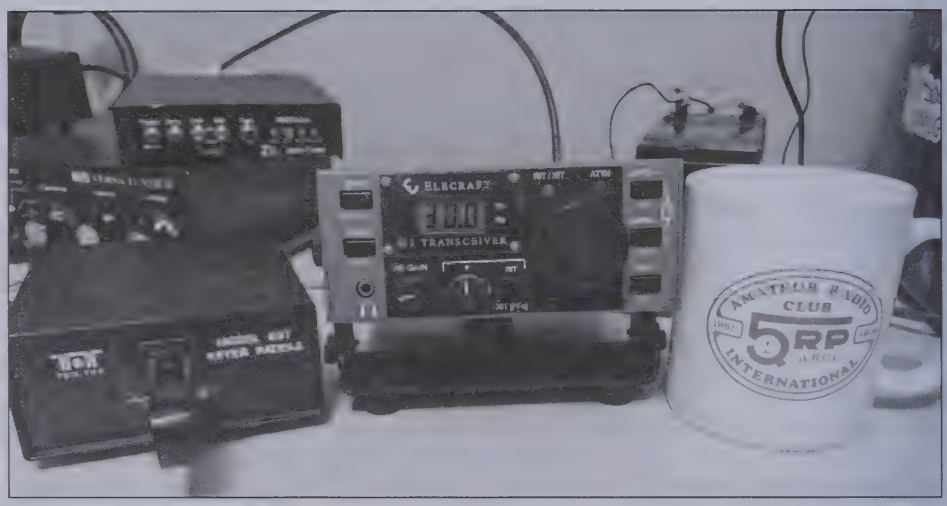
My First Activation

Back in June a few ARCI members, Wayne AC9HP, Ivin W9ILF, and Paul W9PDC contacted me and invited me to join them on an Activation at a nearby park. So I loaded up my Elecraft K1, a battery, headphones, and my Parkwood paddles and headed to the Atterbury Fish and Wildlife Area in central Indiana. I had originally intended on using my PAC-12 antenna but for some reason, I could not get it to tune on any band because I probably put it together wrong. Lucky for me, Ivin had a QRPguys endfed 30m antenna that I borrowed and got on the air.

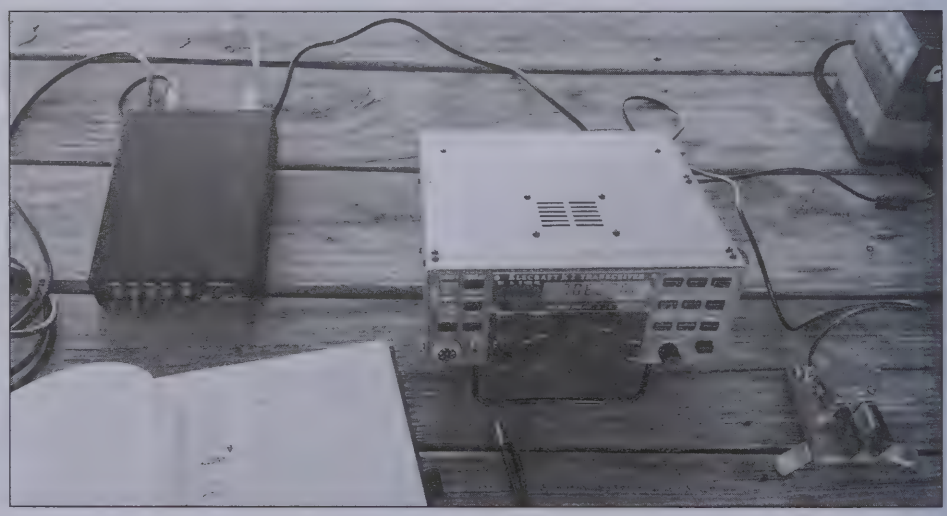
To qualify an Activation in POTA, you have to make 10 contacts minimum. I was running 5 watts of CW to the endfed and managed to get 13 CW contacts on 30m in about an hour. So my first Activation was qualified on the way to the POTA database. That was on June 20th. I was bitten by the POTA bug hard and found myself hunting stations a day or two later. POTA offers a ton of various awards.

As a Hunter you get your first award for contacting 10 different parks, and every 10 parks until you hit 50, then the next one is 75 and then 100. My hunting station consisted of the Elecraft K1

I built in 2002, a LDG Z11 auto tuner, my attic dipole, and an old set of Ten-Tec paddles. I was able to contact my 100th unique park location on August 19th, almost 60 days. All QRP.



This is my current Hunting Station for POTA.



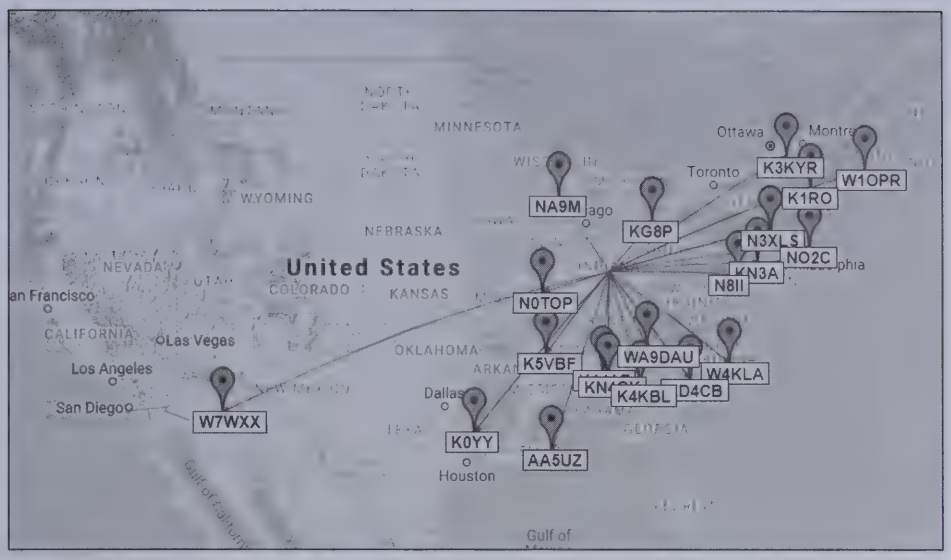
My POTA Activation Station.

I really enjoy hunting the park Activators, I have been working from home since March and this effort gives me some welcome interruptions in my work day. POTA has a great spotting page for the Activator to spot with.

Now, as an Activator, you literally take your station to the field and operate from the location. My Activator station is a Elecraft K2, LDG Z1 Autotuner, Parkwood Paddles, and for an antenna I have a portable vertical antenna called the Eagle One that mounts to the hitch on my SUV.

Since I started Activating near the end of June, I have activated the Atterbury Fish and Wildlife Area five times now. I have logged over 113 QRP CW and 24 QRP SSB contacts from this park location. POTA also offers numerous awards for park activations, and the list of parks numbers in the thousands. At this time only federal and state managed properties are listed in the parks database.

If you have not tried out POTA, I urge you to give it a shot. It is like having Field Day anytime you want! QRP works well in this application and you will be earning POTA awards in no time. POTA is free, the awards are free, and there are no costs associated with participation other than your gear. As you can see the gear does not have to be elaborate.



A map of QSOs during a July 2020 activation (all on 40M).

Above is a map of the QSOs I made during one of my activations, this was running 5w QRP CW to the Eagle One. These are all on 40m, July 10, 2020.

So if you are itching to get out of the cabin, check out Parks on the Air for some great fun and outdoor operating.

—de KB9BVN

●●

An Impedance Mollifier

Seriously, haven't there been a few times when you would like to use just any wire as an antenna? Without an antenna tuner? Perhaps just a clip lead? Maybe something like an old abandoned telephone wire that the Forest Service left strung through the trees a century ago? Here's a way to do that without worries.

This is not a reactance conjugator, not even an impedance transmogrifier. No, this circuit just mollifies the impedance mismatch, soothes and calms it to where it is palatable to the transmitter.

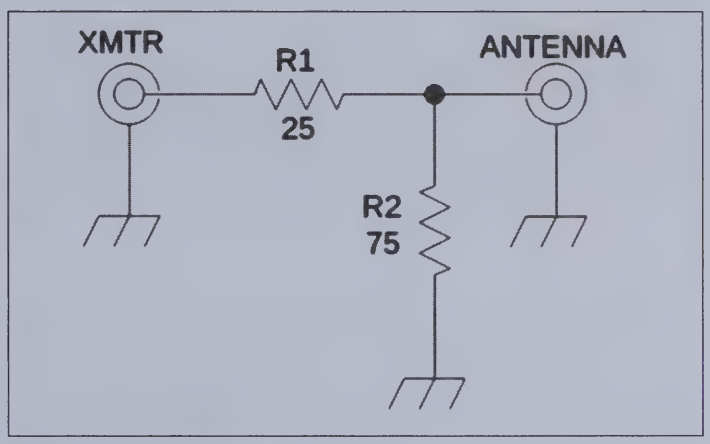
The OzarkCon "Dummy Load Special" antenna (WAØITP, Summer 2008 *QQ* Idea Exchange) came close to this concept by incorporating a resistive dummy load in series with a 40' piece of wire. The military has sometimes used similar configurations for compromise, but rapid deployment, antennas.

The Impedance Mollifier provides further protection and more efficient energy transfer. This is not a new concept but I've never seen anything quite this blatant.

Just two parts!

Two resistors: A 25 ohm resistor in series with the transmitter output and the antenna connection, and a 75 ohm resistor in parallel with the antenna connection. This will limit the overall impedance mismatch to less than 2:1 VSWR. No matter what is (or isn't) attached to the antenna connection.

If the antenna connection is a dead short then the transmitter will "see" a 25 ohm resistive load. If nothing is attached to that connection then the transmitter will be presented with a 100 ohm load. Anything attached will improve that match.



To accommodate these two extremes, R1 (the 25 ohm resistor) needs to be able to dissipate the full output power of the transmitter. R2 (the 75 ohm resistor) needs to be able to dissipate up to 75% of that power.

Naturally, this convenience does come at a cost. Namely, a loss of at least 4.8 dB. That means that if you attach a good antenna and apply 5 watts then 1.6 watts will be radiated. That might be noticed at the far end. Might not! The more egregious the mismatch, the worse the efficiency, but do you really care? This gadget is just to protect the transmitter while allowing anything as an antenna.

No adjustments. No controls. No options. Ultra reliable. Cheap. Compact. So simple that anyone could use it without instruction.

—de KD5KXF

A 75M Vee Dipole

Walter Legan—KA4KXX walteraleg@gmail.com

This is a "Take-What-You-Are-Given" Antenna!

Although it is usually recommended to elevate at least the center of a dipole, as in the popular Inverted Vee, I found an article on the internet that made a decent case for the V-shaped dipole, which just happened to be the only way I could fit a 75 Meter (the only HF band with robust and predictable propagation these days) dipole in my backyard.

I wanted a center-fed antenna because, in this case, my desired operating position was not in my shack at one end of the house, but in my family room at the center of my home, a few feet from my eat-in kitchen.

According to the source listed below, the gain of the Vee antenna is only about 1 dB lower than the standard dipole. Considering that for my Vee installation I only needed 30 feet of coax feedline rather than the 70 feet that would be required for an Inverted Vee or Flat-top, I am probably recapturing most of that 1 dB with lower feedline losses. (www.qsl.net/kk4obi/ Center-fed%20V-dipoles%20Horizontal. html)

Antenna Construction

I first installed the center of the dipole on the outer wall of my back porch (also known here as a "Florida Room"), a few inches below the roof, as shown in the two photos below. Very easily done with only a stepladder! See the two views of the feedpoint in Figure 1.)

Note that for better cosmetics, instead of the standard black RG-58U coax, I used the White "marine" version. This allowed me to run the coax essentially unseen just below the white porch ceiling and inside the house along the light beige wall.

Then I ran the longest pair of wires I could fit (about 58 feet each) to each rear corner of my property, where each of my neighbors has a tree limb overhanging my property, which is only 94 feet wide.

I first tried draping the ends of the wires over the tree limbs, but my digital antenna analyzer told me this was not working well, so I shortened the dipole legs somewhat until they just reached the tree limbs and then added a 1.7 uH coil in series with each wire at the dipole center to achieve resonance, producing an SWR of 1.03 and 49 ohm impedance at 3900 kHz. At the high end of the operating range (3995) the SWR peaks at 1.27, with 1.47 at the low (3820) end.

The sketch in Figure 2 illustrates the configuration, which as a useful bonus probably provides some significant radiation component in all directions.

The next photo (Fig. 3) shows my operating position for the 75M band. Since I am on the air at about around 9 AM in the morning and again at 7 PM in the evening, with the kitchen table just 6 feet to the left, it is very convenient indeed! But perhaps the best part is that I am able to make a contact somewhere in the state of Florida almost every morning or evening, using any of my homebrew 5 watt CW or 10 watt SSB phone transceivers. [The low antenna height delivers high-angle radiation for short-skip/NVIS propagation —*editor*]

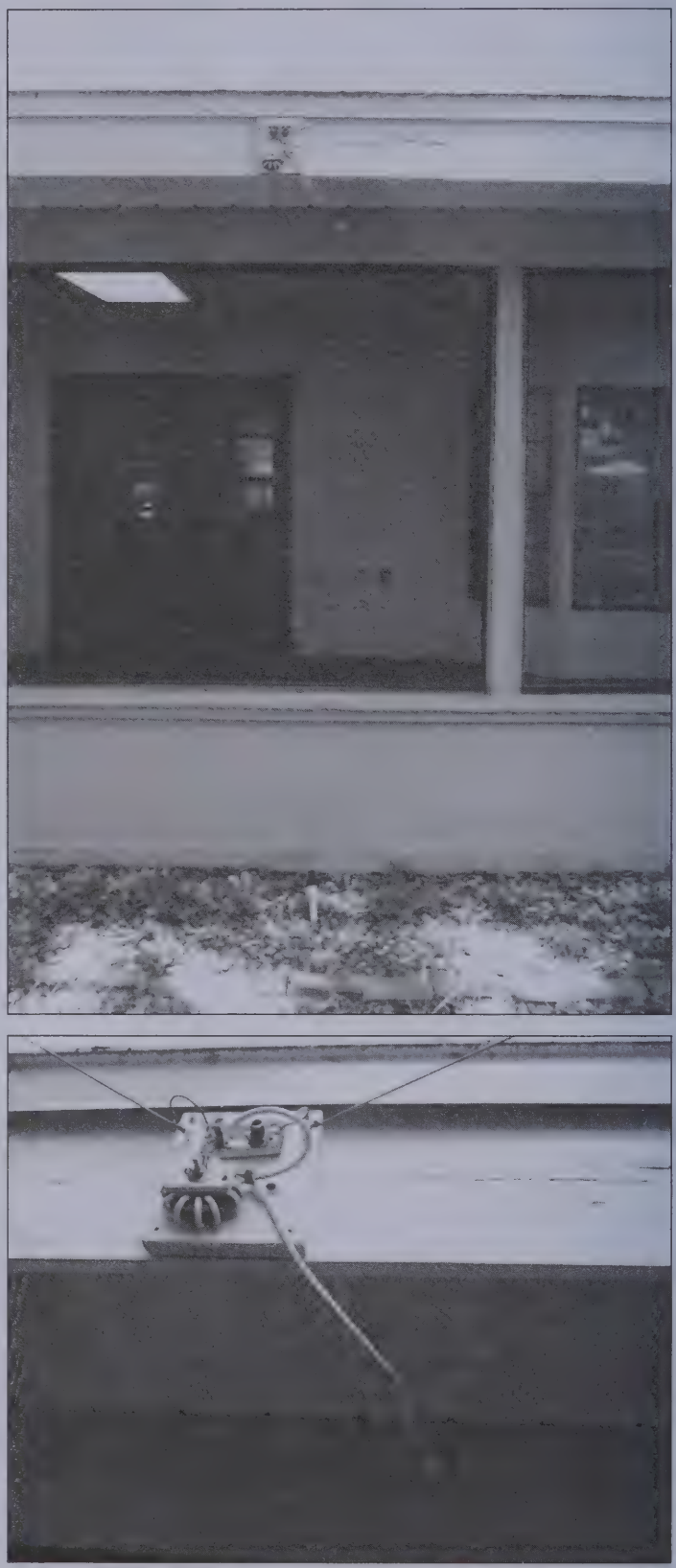


Figure 1—Attachment at the eave of the Florida Room (top), and a close-up view of the feed (bottom).

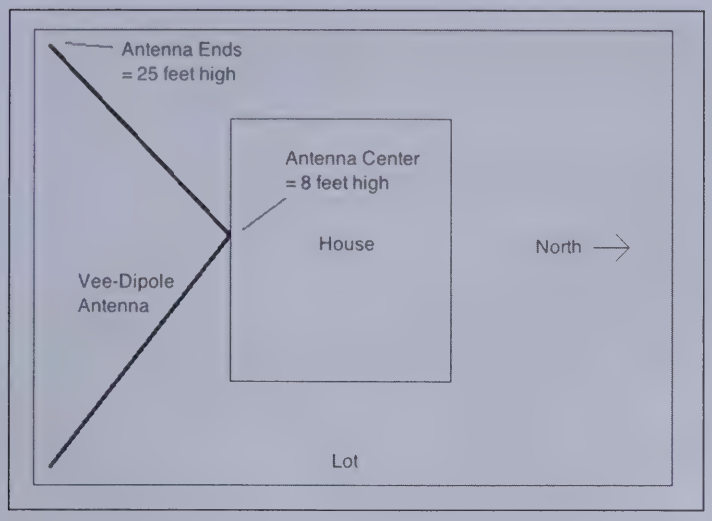


Figure 2—Layout of the antenna on my lot.

As a bonus, the final photo (Fig. 4) shows yours truly modeling a homebrew face shield which I made from a blank page in an old wedding album, a block of foam, and some cloth-covered elastic material. All my friends in the Central Florida QRP Club say I look better this way! ●●

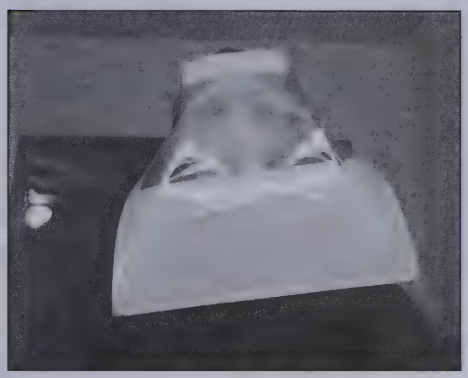


Figure 4

Figure 3—The KA4KXX 75M operating position.

QRP Dream Machines —*de VE3IPS*

Antenna Sleuthing 101

Jack Purdum—W8TEE & Al Peter—AC8GY jjpurdum@yahoo.com & albertfpeter@gmail.com

Some of you know that I enjoy QRP operating and QRP projects in general. To be successful operating at QRP power levels, it really helps of have a good antenna system. The good news is that I live on almost 3 acres of ground that is perfect for a great antenna system. The bad news is that the XYL and I don't see eye-to-eye on what a "great" antenna system is. My antenna system is based on the old saying: "Happy wife, crappy antenna". I have an 80-10M End Fed Half Wave (EFHW) that runs from the house at about 25' height to the top of a silver maple at around 60'. The distance between the house and the tree is such that there's a small downward bend at the tree end of the antenna. The antenna has enough stealth properties to let me continue living here.

Early last Spring a storm packing some significant winds went through, causing the silver maple to sway violently. During that storm, the main support branch holding up my EFHW decided to seek new residence in a nearby state. The end result was my antenna dropped to some lower branches, leaving its midpoint about 10' off the ground. The SWR was still at an acceptable level, so I tried operating with the antenna at its lower position. I think I made fewer than a half-dozen contacts with the "new" location. Not good.

Al has exactly the same antenna, but his starts higher than mine at a two story roof peak and is probably higher at the far end, too. He also faces antenna restrictions, but his are grounded in HOA restrictions. Al and I live about a mile from each other, so it's pretty easy to experiment with things. He agreed to help me reposition my antenna... again.

Al has a Phantom 3 drone with a remote "dropper" doohickey on it. We attached a 1 oz fishing sinker (painted neon yellow for visibility) to a fishing rod with 20 lb test line on it. He then placed the line in the dropper with about 4" of line between it and the sinker. The drone sends a HD image to his cell phone, allowing him to position the drone pretty accurately for the drop. He flew the drone over the top of the silver maple, trailing the fishing line as it went, and triggered the doohickey when he had it positioned where he wanted it to drop. Al removed the sinker and tied on a long length of paracord, wrapping the fishing-line/paracord junction with tape so it wouldn't snag in the tree as I reeled in the fishing line. When the paracord was over the tree, I grabbed it, cut the paracord, passed it through the antenna's egg insulator and melted/knotted the line. Al then pulled the paracord back over the top of the tree. Voila!

After Al gathered up his tools, I went to the shack, flipped on my transceiver and antenna tuner. The SWR looked pretty good (i.e., below 1.5:1), and I quickly made several contacts, albeit running high power (i.e., 100W). I was very happy to be back on the air.

The next day, Al came back over to check the antenna with his Mini1300 VNA/Antenna Analyzer "just to make sure" everything was right. He took one quick glance at the VNA display and announced: "That's not right." Because we run the same antenna in similar space, he knew what to expect when the VNA finished its frequency scan. The scan he expected to see should be very similar to his own antenna scan, like that shown in shown in

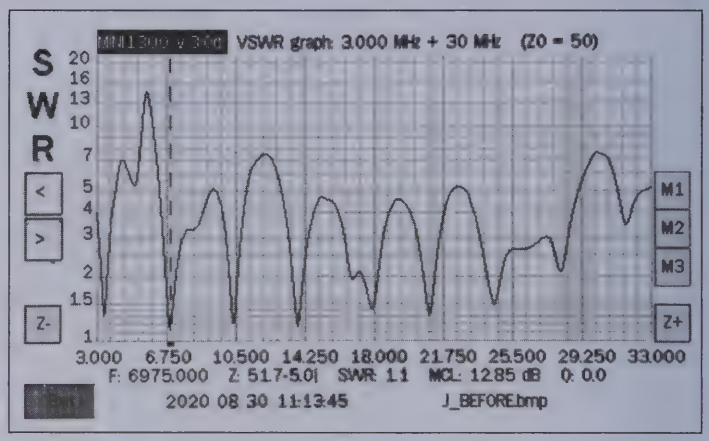


Figure 1—Initial VNA scan of my 80-10M EFHW antenna.

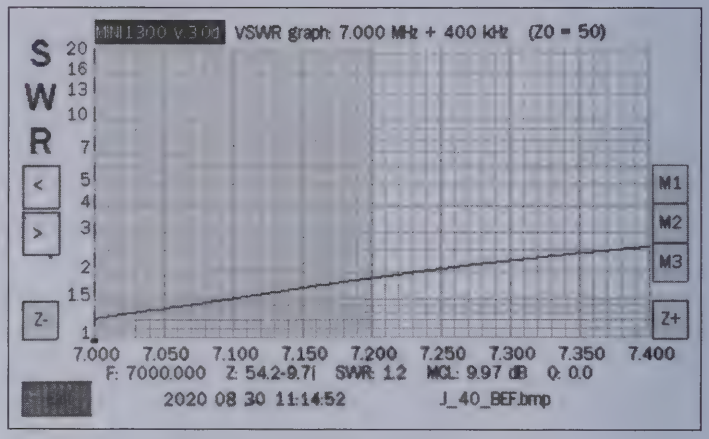


Figure 2—SWR at 40M, original length.

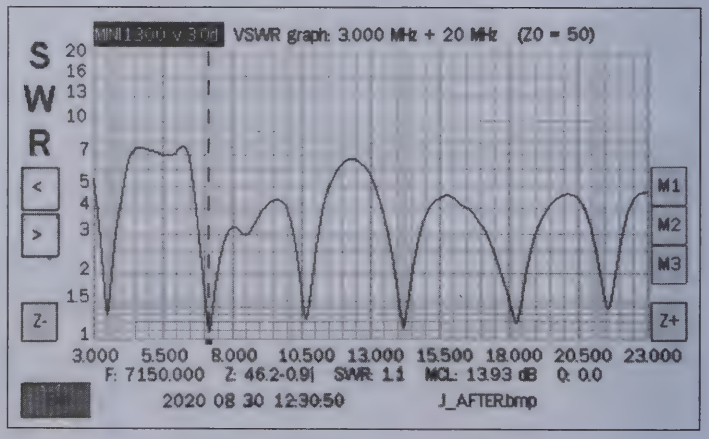


Figure 3—Shortened antenna SWR response.

Figure 1. The problem was two-fold. First, the resonances (low point in the SWR plot were all below the US ham bands, indicating that the antenna wire was slightly long.) The second problem was evident when the antenna switch was used to be able to select between my various radios. The SWR plot actually looked like

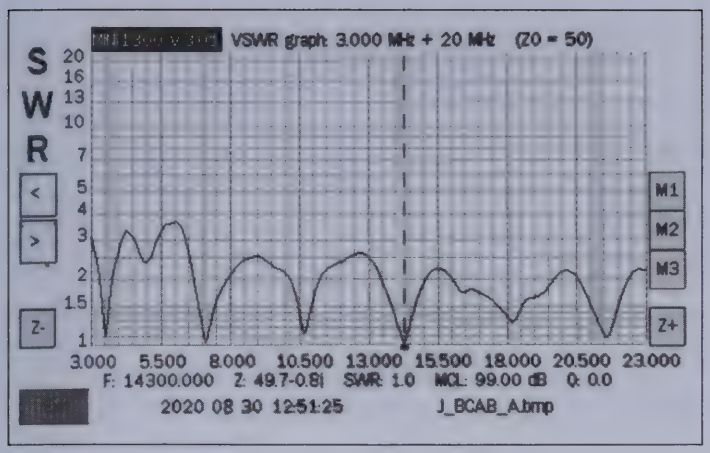


Figure 4—Shortened antenna with length of RG8 added to bring signal into shack.

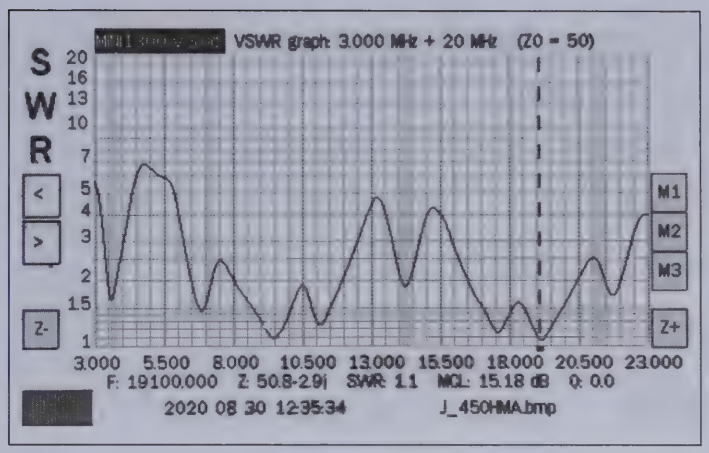


Figure 5 SWR in shack with Antenna Switch. This data revealed that the switch had problems!

Figure 5 below, with very different results. That is when Al went on an "antenna sleuthing" hunt for the culprit.

The first test was taken outside the shack, with a short length of LM400 coax leading down from the roof, shown in Figure 1. We started there to eliminate antenna variables one by one. Outside, SWR values were acceptably low for each band and the SWR rises between each resonant minimum, as expected, indicating generally low losses in the system. However, while the SWR minimums are all low, the resonance frequencies were below the ham band edges. This indicates that the antenna was too long. The probable cause is the added capacitance from proximity to the tree leaves/branches at the end of the antenna wire, which by necessity is located within the tall tree. The remedy is to shorten the antenna. Consulting an EFHW calculator, we determined that approximately 3.5' should be trimmed from the antenna wire. Figure 2 is a scan of the 40M band showing the original length SWR. Clearly, the minimum SWR is below the lower 40M band edge.

Figure 3 shows the SWR plot after removing 3.5' of the antenna length. In this case, "removing" means folding the extra 3.5' of wire back on itself after passing through the insulator and clamping it in place. That way, if we had a hiccup in the math, we could undo the "removal". (It's a MyAntenna brand that includes stainless hardware clamps at the antenna insulator.) Note that the resonance frequencies have all moved up into the 80, 40 and 20M bands. The Figure 3 plot was also taken outside the shack. Multiband antennas such as this are compromises at best, so our objective was to be optimized for 40M and 20M, which are my most-used bands, with at least an acceptable result at 80M.

A length of RG8 coax brings the signal into the shack. The SWR plot seen in Figure 4 now shows the same resonances as before, but with lower SWR values at their minimums. That's the good news. The bad news is the reduced SWR values between resonances. (Compare the peaks in Figure 3 with those shown in Figure 4.)

The new responses in Figure 4 are indicative of added resistance in the coax cable. Sure enough, the added cable length had about 5 ohms of series resistance in the braid. The cable had been outside in the weather for about 2 years and was now defective. (Al confirmed this by doing a Time Domain Reflectometer (TDR) test on the cable, as well as measuring the DC resistance.) This cable was discarded and another length of LM400 used instead. The added resistance from the defective braid in the old cable gave false low SWR readings. These bogus SWR readings would have resulted in increased power losses in the cable, despite the observed lower SWR readings.

After replacing the defective cable, we hooked up to the transceiver, but this time placed the VNA after the antenna switch. The SWR, measured at the transmitter and shown in Figure 5, looked terrible. SWR at resonance was up and the plot again suggested high resistance. Sure enough, the switch had series resistance values ranging from 1 ohm to 60 ohms depending on how you jiggled the switch. The plot in Figure 5 shows the result of about 45 ohms series resistance. Replacing the switch fixed the problem. (BTW, the defective antenna switch wasn't cheap and I purchased it brand new. The replacement switch is two years younger than dirt and was purchased at a hamfest for $5! There are some great bargains in those tailgates!)

Finally, detailed SWR plots were obtained for the most used bands, as shown in Figures 6, 7 and 8.

Figure 6 shows the 80M result and indicates that the resonance has been moved to just below the lower band limit. This is probably OK, because the 40M and 20M band minimum SWR results are within the bands.

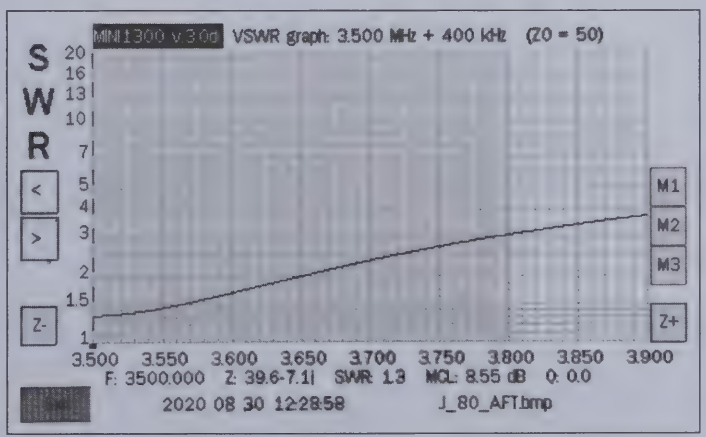


Figure 6—Final 80M SWR. I can live with the resonance below the band, since 40M and 20M are optimized.

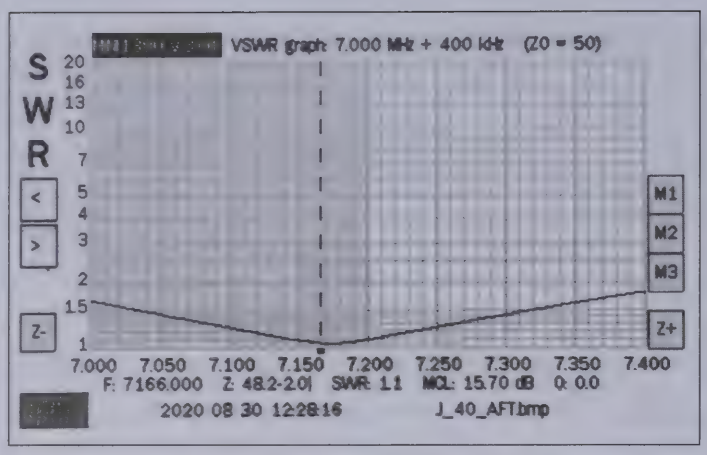


Figure 7—40M band result after shortening.

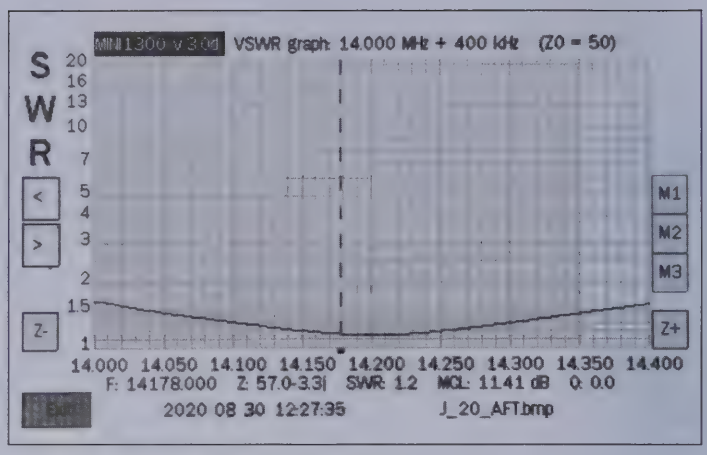


Figure 8—Final result for 20M band.

Figure 7 shows the 40M result after shortening. The SWR at minimum is an excellent 1.1 value, right in the center of the band. Perfect! Compare that to Figure 2, before shortening.

Finally, Figure 8 shows the result at 20M. The SWR is excellent at 1.2, again virtually dead-center in the band.

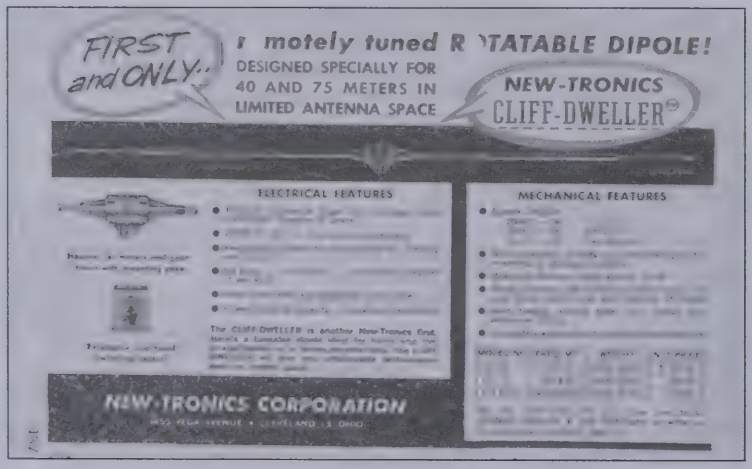
I'm going to have to fight Al for this last paragraph, but I wonder how many of us are like me. You put up an antenna, look at the SWR, make a few quick contacts, and say "Perfect!". Frankly, I don't have enough electronics or antenna knowledge to know better, but it took Al just under two nanoseconds to look at the plot and know that something was amiss. Even worse, it's one thing to lose 25% of your power to heat when you're running 1 kW but a little different when you are coaxing 5W into a less than ideal antenna. This little foray into resetting my antenna has caused me to read up on antenna theory and I'm all the better for it. If you're into QRP like I am, you already know that the antenna system is crucial to really enjoying QRP operation. By the way, this exercise is valid no matter the power you use. The moral: A low SWR is only part of the story your antenna system is telling you. Perhaps you, too, would benefit from a little additional antenna sleuthing!

●●

A Little History: The Newtronics Cliff Dweller Antenna CD-40-75 Remotely Tuned Rotary Dipole Antenna

In the 60s and 70s there was a motorized telescopic dipole on the market that covered 80 and 40m operating as a retractable rotary dipole antenna. Each half element is composed of a spiral wire that the motor stretched inside an insulating tube. The CliffDwellers were manufactured and sold by New-Tronics. Manufacturing stopped at the beginning of the '70s, with the unreliability of the gear motor block being the weak point of the product. *—de John, VE3IPS*

Advertisements for the "Cliff-Dweller" NEW-TRONICS, Model CD 40-75
The left one is from QST, p. 138, Dec. 1964.


FIRST and ONLY..
r motely tuned R TATABLE DIPOLE!
DESIGNED SPECIALLY FOR 40 AND 75 METERS IN LIMITED ANTENNA SPACE
NEW-TRONICS CLIFF-DWELLER®
ELECTRICAL FEATURES
MECHANICAL FEATURES
NEW-TRONICS CORPORATION

Modify an MFJ Mast for Use With a Buddipole

Al Duncan—VE3RRD ve3rrd@rac.ca

I recently acquired an almost new MFJ-1919EX heavy duty tripod with fibreglass telescoping mast that extends to 18 feet. The top section tube is 3/4 inch outside diameter with a 1/2 inch inside diameter, but the only way I could see to mount an antenna to it was with clamps, which wouldn't work very well for the Buddipole. The solution was a 1/2 inch insert to 1/2 inch male pipe thread brass hose connector. The one I found at Home Hardware (D125-8D-BRASS, stock #8690179) would extend down into the top fibreglass section far enough for strength and screwed into the Buddipole VersaTee securely.

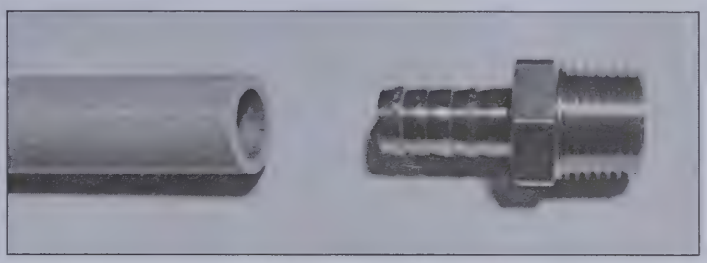
I had to file the ridges slightly so that it would fit snugly so it can't turn, but not too tightly into the mast top section as it could crack the fibreglass.

Guy ropes/cords will be required when using this fully extended outdoors. A triangular piece of heavy plastic or a piece of aluminum with a 3/4 inch hole in the centre and smaller holes in each corner can be used. I hack-sawed out a triangular piece of 1/16 inch thick aluminum about 3-1/4 inches on a side for my guy attachment plate. The top mast section can be removed and the guying plate slipped over the bottom end.

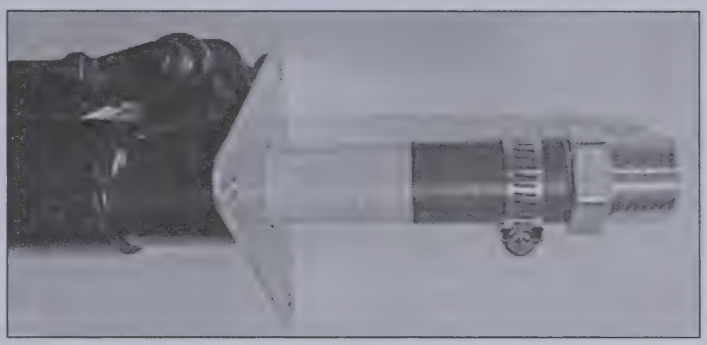
I added a small hose clamp to help prevent damage to the fibreglass from the torque produced on a windy day. The top end of the tube was filled with a hard glue-like substance so I flipped it over and used the other end for the adapter. I drilled a hole through the glue to allow moisture to drain, but I will be sealing the hole in the 1/2 inch brass adapter.

Raising the Buddipole up to double the standard 9 foot height definitely improves its performance when using it with my KX3. I also have the long telescopic whips and an extra 22 inch antenna arm for each side plus the TRSB to create what some have called "the Super Deluxe Buddipole". The extra wind loading and weight with everything attached does require a sturdy tripod and mast as it is almost 27 feet from tip to tip with whips fully extended. The rotating arm kit is needed since you must angle the antenna arms up one notch to compensate for the sag.

I use an 18 inch long screw-in type dog anchor under the tripod, attached with a hefty bungee cord to keep the fully loaded mast from possibly tipping over as I am raising/lowering the antenna. A suitable weight could be used instead of the dog anchor if setting up on a cement or paved surface. This takes care of the base, although you may have to be creative when finding the three guy anchor points. At the end of each guy cord, I use a one inch S-hook with one end squeezed closed, for easy attachment to the guy plate. The other ends may be plain for tying, or you might use some other connector of your choice.

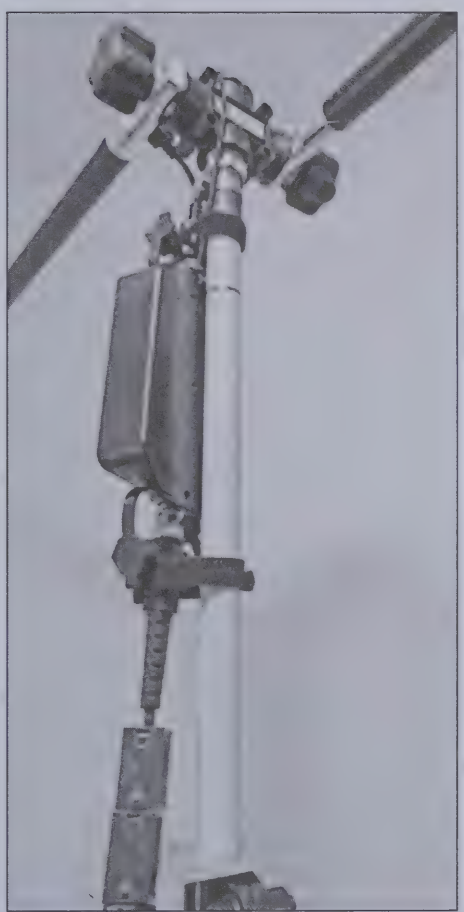


Top mast section and 1/2 inch to 1/2 inch adapter.



Finished installation with heat-shrink and hose clamp added with aluminum guy attachment plate

MFJ-1919EX



With the Buddipole in place

How to Build the KW4JM Vertical

Martin Huyett—KØBXB & Scott Carter—KW4JM

This antenna is essentially a 20-meter 1/4 wave vertical with a center loading coil for lower bands. I built it for 20, 30 and 40 meters, so there is one 16 ft radial for 20 meters, a 23 ft radial for 30 meters and a 33 ft radial for 40 meters. All three radials are connected simultaneously. The loading coil which is about 1/5th of the way up from the bottom of the vertical element has a tap for each band of the three bands

What You'll Need

Coil Form—I used a piece cut from a 1-1/2 inch O.D Sink Tailpiece from the local hardware store. The exact diameter is not critical.

Wire—You'll need 50 to 75 feet of small stranded wirefor the coil, the top and bottom elements and the radials. I used a 100 ft. pack of 24 Gauge RCA Speaker Wire. I split the two wires apart and used only one.

Brass Screw Eyes—You want the smallest brass screw eyes you can find. I used #6 ones. You'll need one for each band. You could substitute a small screw. They need to be small enough to pierce but not destroy the stranded wire and long enough to allow you to attach an alligator clip.

Electrical tape and shrink wrap tubing— The tape will be used to secure the windings temporarily and perhaps permanently!

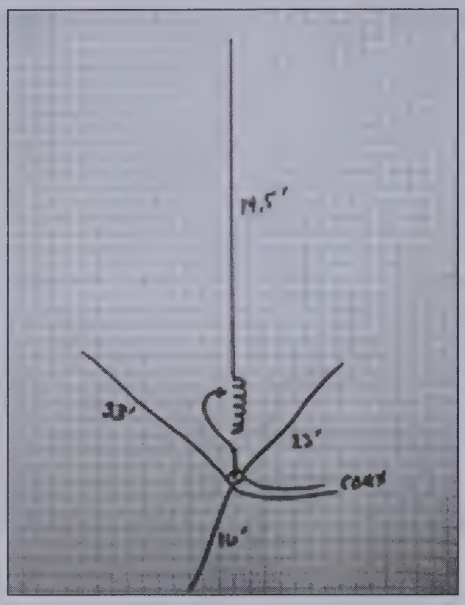
A small alligator clip—This will be soldered to a pigtail that connects the lower element to the appropriate tap on the coil for the band you select allowing easy band changing!

Banana plugs and jacks—I used four pairs to connect my upper and lower elements to the coil and the lower element to the feedline. I also connected the radials to the feedline using one of these.

BNC to Banana jack adapter—I used one of these to connect my feedline to the antenna and radials.

Straight pins

Antenna analyzer or some way to measure SWR—I used my NanoVNA for this which was a big help since it can show a very wide frequency range. Any good SWR meter will work.



Design of the KW4JM vertical. Basically, it is a 20M vertical with loading coils and radials for lower frequency bands.

Time to Build

Begin by drilling a small hole about an inch from the top end of your coil form. Make the hole just large enough for the insulated wire to pass through. Pull about 12-1/2 feet or a bit more of your wire through the hole from the outside to form the upper element and tie a knot in the wire at that point. The knot should be inside the coil form. Don't cut the wire off the roll as you will not wind the coil.

Now cut a couple pieces of electrical tape about an inch or more long and keep them and a felt tip pen handy.

Begin winding the coil by pulling the knot in the wire gently against the inside of the form and wind the wire around the form. Keep each turn snug against the previous turn and firmly against the form. Every five turns mark a small line on the wire with your felt tip pen to make it easier to count turns later. When winding and keeping the turns snug and tight gets difficult, put a piece of tape on it so the completed turns will stay put as you continue winding.

I suggest that you wind 90 or a hundred turns if you want to include 60 and 80 meters. If you only plan to make the antenna for 40, 30 and 20 meters you can stop at 70 or 80 turns. It is best to wind more than you will likely need. You can always remove the extra.

Now tape the end of the last turn securely to keep the coil firmly in place so there is no chance of it coming loose which will ruin your day! Cut off the excess wire. You should now have your form with the wound coil and 12-1/2 or so wire protruding from the top.

Next drill another small hole about an inch or so beyond the last turn of your winding.

Cut a piece of wire about six feet long and tie a knot about a foot from one end. Pass the one-foot end through the hole you just drilled from the inside up to the knot and tape it in place.

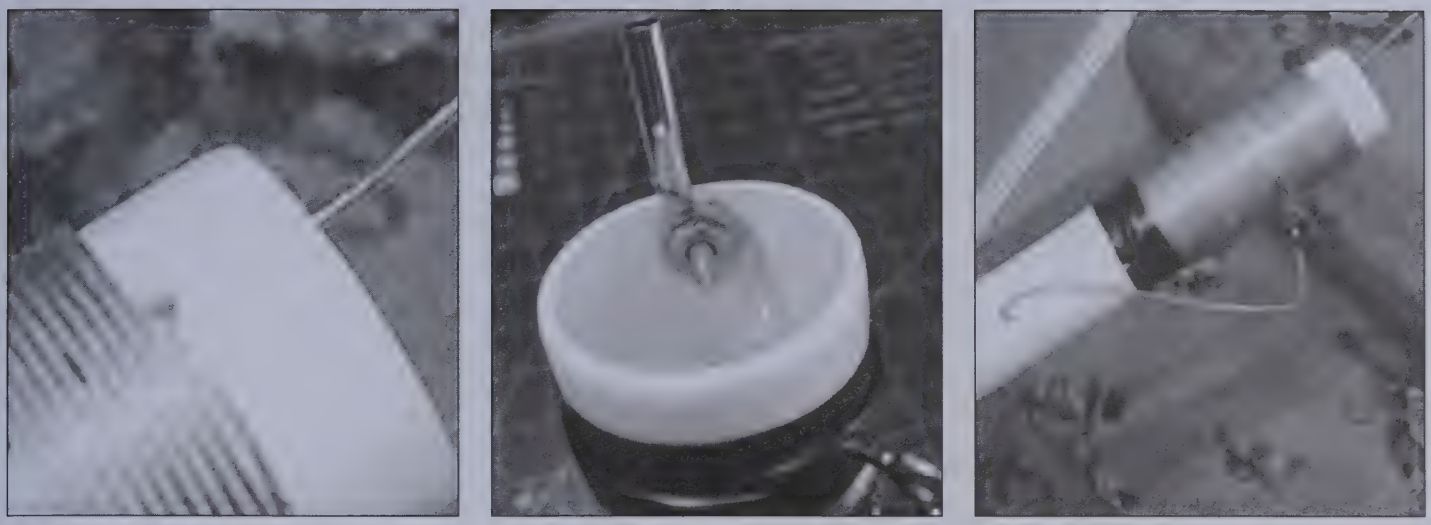
You should now have the wound coil form with twelve feet of wire protruding from inside the top and five or so feet of wire protruding from inside the bottom, and a one foot pigtail coming out the side through the bottom hole. You have completed the simplest and easiest part!

You can do your initial tuning for 20 meters by trimming either the top 12 ft element or the bottom five foot one. It's easier to trim the bottom one. The exact length of each is not critical.It is the combined overall length that is important.

Form a loop in the top end of the 12-foot wire by bending it back on itself a couple inches and tape it in place leaving a half inch or so loop for tying the top end to a rope. This will make it easy to suspend the antenna during tuning.

Slip a 1-1/4 inch piece of heat shrink tubing over the one-foot pigtail coming out of the bottom hole in the form, and trim the pigtail so it easily reaches the top of the coil form with a couple inches to spare. Now strip the wire and solder your alligator clip to the end. Slide the piece of heat shrink tubing over the back of the alligator clip and shrink it into place providing a neat and somewhat rugged result.

Now cut a 33 foot length, a 23 foot length and a 16 foot length of wire. Strip 1/2 inch from one end of each and twist the three stripped ends together and solder the twisted ends of the radials a banana plug. Shrink a 1-1/4 inch or so piece of heat



Steps in the construction of the antenna: winding the coil, attaching connectors, and the final arrangement with tap in place.

shrink tube over the plug shoulder and up the wires a ways to protect the wires and give you a handle to unplug the radials without breaking them.

Hanging and Tuning the Antenna

Now we are coming to the fun part, tuning up the antenna. Suspend it from a tree branch that is easy to get a lightweight rope over from a collapsible fiberglass fishing pole or mast around 20 feet long.

With the antenna suspended so the bottom is two or three feet off the ground, grab your BNC Banana jack adaptor and attach the bottom wire from the coil form onto the red terminal or banana jack. Plug the radials into the black banana jack and fan them out approximately evenly and tie them to nearby bushes, or stakes so they stay a foot or so off the ground with the center point more-or-less directly below the top of the antenna. Then connect your coax to the BNC jack and to your antenna analyzer or rig.

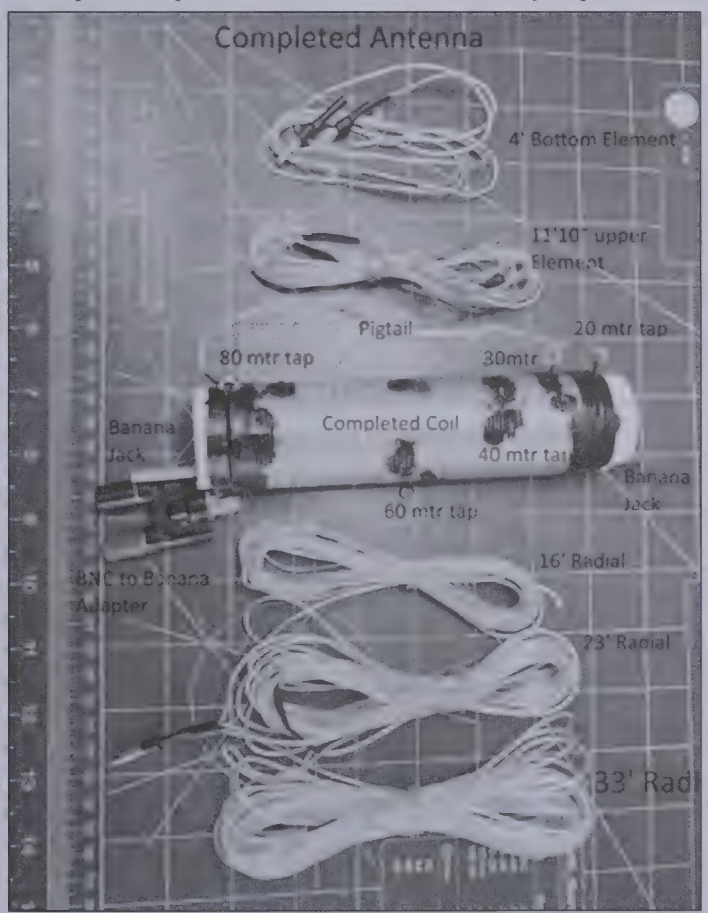
Press a straight pin through the insulation and into the wire of the top winding of the coil a half inch or so back from the hole in the form and gently clip the alligator clip to the pin being careful not to pull the pin out of the winding. This bypasses the coil so you can adjust the wire length to resonate on 20 meters.

Using your antenna analyzer or rig, find where the antenna is currently resonant. Hopefully, it is below 14.00 MHz. It may be way below depending on the combined length of the top element, pigtail and bottom element. Once you find the resonant frequency, trim the bottom element an inch or so at a time until it resonates near the center of the 20 meter band, about 14.20 MHz.The length of the bottom element will be somewhere near 4 feet. If the initial resonant frequency is above the 20 meter band, you'll need to add wire to either the top or bottom element until it is resonant at 14.2 MHz. Mark the location of the straight pin with the felt tip marker as you'll need to put a screw eye there later.

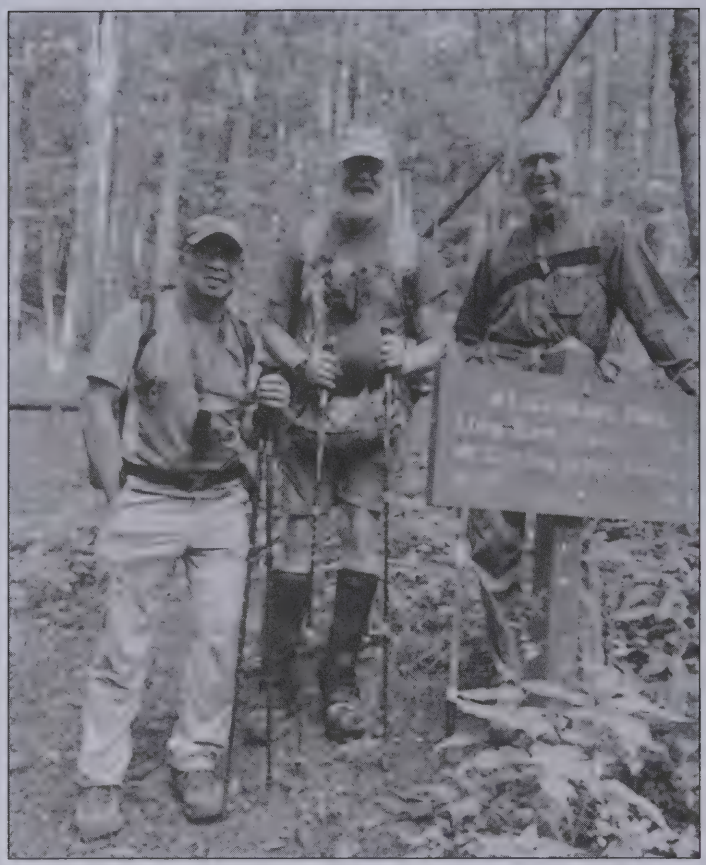
Next, push the straight pin through the 10th or 12th winding from the top of the coil. Clip the alligator clip to that pin and find where it is resonant. If it is below about 10.12 MHz, move the pin up a winding and check again. If it is above 10.12 MHz, move the pin down a turn. You may need to move the pin part of a turn around to form, adding or removing a half turn or so, to find the magic spot. Mark that spot with your felt tip marker as above.

NOTE: DO NOT CHANGE THE LENGTH OF THE WIRE ELEMENTS AT THIS POINT or you'll have to start all over. The antenna, with the coil bypassed, is a 1/4 wavelength resonant vertical on 20 meters. The coil taps change the effective length to resonate on the lower frequencies.

Repeat this process for each band for which you plan to use



The completed antenna, with coil, vertical wires and radials for each of the bands.



NY4G With Dean K2JB and Scott KW4JM at Mount Sterling Trailhead.

the antenna. It's a good idea to double check your work as now is the easiest time to make changes in tap locations.

Finalizing the antenna

Finalize the antenna by adding the screw eyes, removing unneeded windings, trimming the coil form and making it all somewhat robust.

To install the screw eyes I found the simplest way is to get an awl or some other small, sharply pointed pick and carefully press it through the center of the wire where you marked each straight pin location. Press hard enough to make a dimple in the coil form beneath the winding. Try to get the awl through the center of the small small wires without breaking many of them.

Choose a drill bit that is just right to make a hole that the screw eye will thread into snugly. Smaller is better than larger. Carefully press the windings away from the dimple you just made and drill a hole. Now carefully move the winding you pierced back over the hole and gently screw the screw eye through the winding and into the drilled hole.

Once you have all the screw eyes in place, hang and re-test to be sure it resonates in each band as you want. If not, you can remove a screw eye and carefully close the hole in the winding and relocate it where it should be.

Finally, trim off any unneeded windings from the bottom of the coil, leaving a little excess wire and tape both ends of the winding securely to keep them in place. You can now cut off the excess coil form, drill a new hole for the lower element if needed and reinstall it.

Solder a banana bullet to the bottom end of the lower element and add shrink tubing so you can simply plug it into the red banana jack on the BNC to Banana adapter rather than having to screw it under the cap.

Put it on the air!

https://www.huyettm.net/make-a-kw4jm-vertical.html

I made twenty-six contacts with mine in February right after completing it! Distances ranged from just over 4000 miles with a ham in France and about 300 miles. Five of those were running 5 watts, the rest, 20 watts. Five of the 40 meter contacts were SSB, all the others were CW. Three were on 20 meters, including the one to France. Five were on 30 meters and the rest were on 40 meters. I experimented with adjusting it with the coil at the bottom rather than elevated. I believe it worked about as well but did not do a lot of testing with it.

It was a fun and practical project giving me one more easily portable antenna. ●●

Another Antenna Note from John, VE3IPS:

The Classic Doublet Antenna with Extensions for 75 meter Phone or 80m CW

This antenna has become a classic antenna for QRP operators. It is easy to build and works well with any tuner. The antenna can be quickly deployed and offers coverage down to 40m. It is a 44 foot doublet (22 feet) on each side of center) with a feed line of 22 feet of 450 ohm window line. Variations of using zip cord or speaker cable as twin lead has also been used with great success. In my case, the center is supported by a 20 foot telescoping painter's handle with a hook at the top made out of a paint roller, or I may use a 20 foot Crappie fishing pole.

I have 22 foot extensions I can add to each side of the doublet to make it 88 feet for use on our 75 meter SSB net or the CW portion of the band.

If I want to work 160 meters you can tie the two sides of the 22 foot feed line together make a top loaded vertical with the extensions in place. Since it is a vertical, a good ground is needed!

The QEC-Match Delta Loop Antenna

Akira Motohashi—JP1QEC

Editor VE3IPS: I plan to use 2 AT-271 whips with some #26 wire and some alligator clips. And a LDG 4:1 Balun

The QEC-Match Delta Loop

The recipe is for the QEC-match Delta-Loop. I tested it between 70cm and 10m, and all antennas worked well. If you have parallel cord for DC power line, let's make a great Delta Loop antenna including a Q-match section.

The parallel DC cord has about 110 ohm characteristic resistance. So, we can make a QEC-match section for about 200 ohm input impedance of an antenna. For example, A Delta Loop antenna having a 60 degree angle has about 110 ohm input impedance, but the impedance changes to higher value by making longer the element on the counter side of the feeding point.

Therefore, we can make a delta loop antenna including Q-match section by using one parallel cord, by the following procedure:

(1) Prepare a parallel line with the length of 1/2 lambda x 1.06 + QEC-match section (1/4 lambda x 0.65). The 0.65 is the shortening ratio of parallel cord length, and 1.06 is the ratio of the element length.
(2) 2 wires at one end of the line are soldered each other
(3) Attach a connector at the other end of the line
(4) Split the parallel cord, from the soldered tip to the position of 1/2 lambda x 0.97

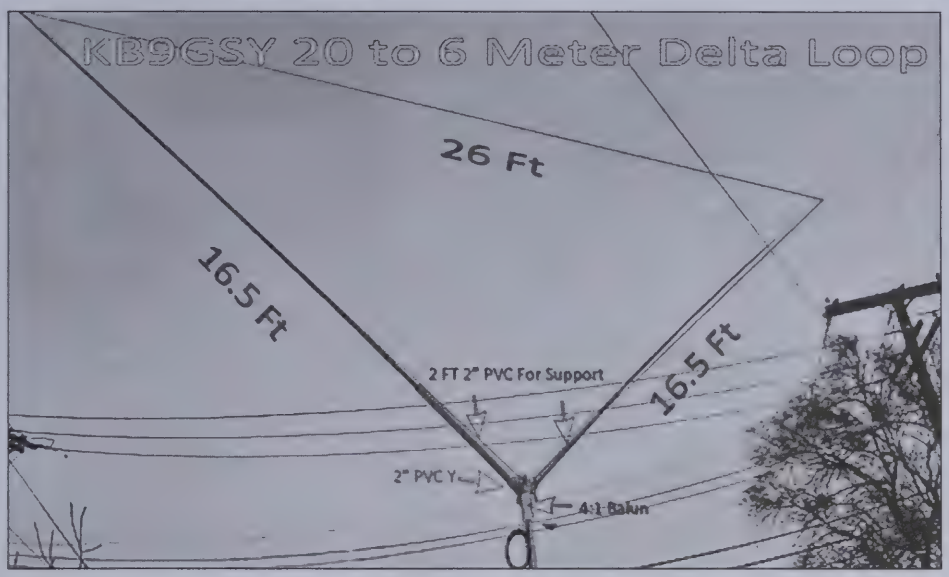
The drawings show how the antenna is constructed.

Adjustment

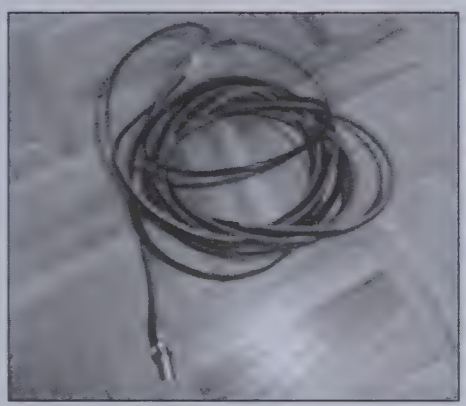
Adjust the length of the opposite side element of the feeding point until the SWR becomes low. You don't need cut the wire but change the length of the distribution.

L (meters) is the total length of the parallel cord. And *d* (m) is the QEC-match length. *f* (MHz) is the target frequency.

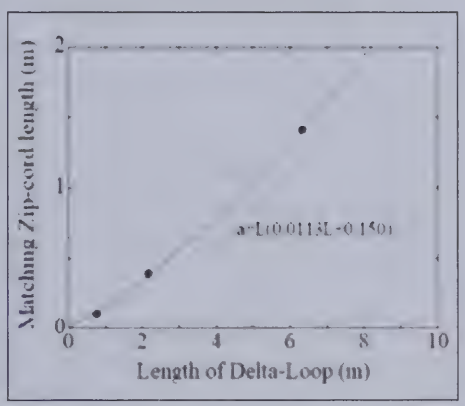
$L = 208.5/f$
$d = 49.5/f$



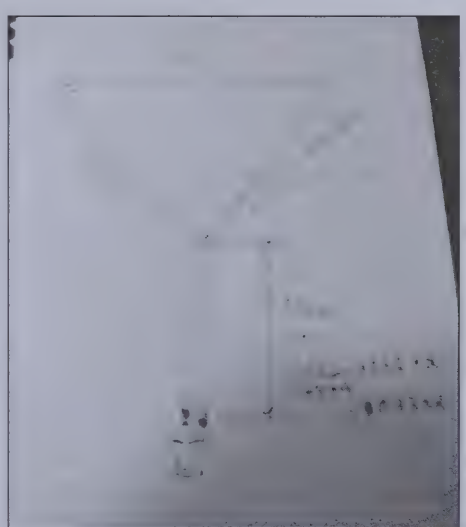
KB9GSY's Tactical Delta Loop, similar to VE3IPS' plans.
Warning! Watch out for power lines when installing and using antennas!

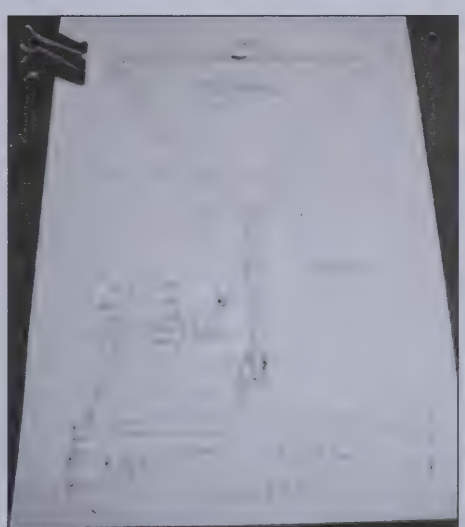


Here is the wire after assembly.



Ratio of matching section to total length.





Construction details of the QEC-Match Delta Loop.

In case of 51 MHz,

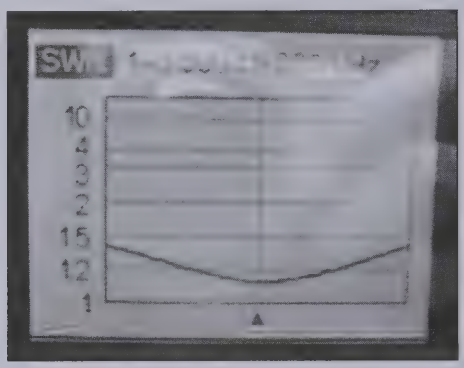
$L = 4.09$m
$d = 0.97$m

The impedance of the delta-loop with 60 degree has about 110 ohm. But, this impedance is not changed to 50 ohm by QEC-match.

So, we need to open larger angle until the SWR<1.5 like the picture.

For 6m I used 3.164 m for the delta loop and 0.965m for the QEC-match section. This 6m antenna can also be QRV on 145 MHz without change (as you can see in the SWR photo).

—Akira, JP1QEC



SWR plot on an antenna analyzer.

Web References

https://youtu.be/FOLJgFq9MZA
https://www.qrz.com/db/JP1QEC
https://www.fbnews.jp/201803/sota/index.html

Editor's Note: This antenna took very little time to make for 6m. It would be horizontally polarized. I found I could adjust the SWR by varying the angle at the bottom of the Delta which in turn changes the side lengths that Akira mentions. —VE3IPS

A few of JP1QEC's adventures

Here is How QRP ARCI Membership Works...

New members join QRP ARCI by taking a subscription to *QRP Quarterly* magazine. A membership number will be issued after joining. Membership is for life.

A member with a current subscription to *QRP Quarterly* is an 'active member'. An active member can apply for up to 5 QRP ARCI operating awards each year (issued free of charge) and has voting rights in QRP ARCI elections and polls.

An inactive member has let their *QQ* subscription lapse. The membership number is still valid for use in contests. Active membership can be restored by resubscribing to *QRP Quarterly* magazine.

A Wattmeter-Only Version of the WD9HNU Design

Keith Kunde—K8KK k8kk@arrl.net

Here's a wattmeter-only version of the "Linear Scale QRP Wattmeter with SWR Indicator" by Fred Piering, WD9HNU, that was published in October, 2019 *QST*. I adapted the linear-scale wattmeter portion of Fred's innovative, highly-integrated design to make a single-power range, QRP wattmeter with a digital display of forward and reflected power. The cut-down design reduces the unit cost while the use of through-hole components eases construction. By happy coincidence, the digital meter I selected enables the unit to display up to 20 watts of RF power.

The finished QRP wattmeter, with simple operation and a digital display.

Circuit Overview

Please refer to the revised schematic in Figure 1. The pricey Mini-Circuits 20 dB bi-directional coupler in WD9HNU's design ($50.00 minimum order) has been replaced by an inexpensive home-brew version using two toroids, similar to the coupler used in the old Tandem Match (Figure 2). While a -20 dB coupler (i.e., output = 0.01 x input power or 0.1 x input voltage) requires just a single ten-turn winding per toroid, care must be taken to assure that the winding's inductive reactance (X_L) is high enough to permit operation on 160 or even 80 meters without excessive power loss in the coupler. An X_L that is about 10 times the 50 ohm line impedance at 1.8 MHz will be reasonably efficient. A ten-turn winding on a high-permeability ($\mu = 850$) ferrite core having an A_L factor centered in the 440 nH/t^2 (nanoHenrys per turns squared, ±20%) range, such as a type FT-50-43, will have approximately 44 microHenrys (µH) inductance and about 500 ohms X_L at 1.8 MHz. Adding a single -20 dB resistive input attenuator gives the total of-40 dB required to put the full-scale power (originally 10, now 20 watts) within the input range of the AD8361power detector chip, while still allowing accurate readings for RF inputs well below one watt.

A 3PDT switch on the front panel, connected to the coupler and circuit board with phono plugs and RG-174 coaxial cable,reverses the forward and reflected power outputs of the coupler so that only one power detector chip is needed. A single LT1077C precision op-amp buffer provides a low-impedance drive for the AD633 analog multiplier chip, thereby reducing the potential effects of the AD633's input bias currents on low-level meter readings. Resistors at the outputs of the detector (15kΩ) and buffer (5.1kΩ) further reduce their small voltage offsets when their outputs are saturated near zero volts, yet add less than 1 mA to the battery load. A second 9-volt battery supplies the low-current negative voltage required by the AD633.

Metering Circuit Changes

To review, in WD9HNU's original metering circuit, Fred used the voltage output configuration of the AD633 multiplier chip to drive an imported 1-mA analog meter having an internal resistance of 254 ohms. With 10 watts RF input, the-40 dB coupler/attenuator input to the power detector chip results in a V/Vrms conversion output level of (nominally, using WD9HNU's numbers) 1.6 VDC going to both the X and Y inputs of the multiplier. The multiplier squares this to 2.56 V and then divides it by 10 (default), giving 0.256 V at the output. That voltage, when divided by the meter's resistance of 254 ohms, results in approximately 1 mA through the meter circuit, trimmed to exactly 1 mA by a 100 Ω potentiometer in series with the meter.

Note that the AD8361 power detector chip has a Vrms-to-VDC conversion gain that can range anywhere from 6.5 to 8.5, according to the data sheet. In the example above, 10 watts into 50 Ω results in 22.36 Vrms across the load as input to the wattmeter. After the -40 dB total input attenuation (0.1 x 0.1, or 0.01 of the RMS voltage), 223.6 mVrms remains. With this input, the detector's output can range anywhere from 1.453 to 1.901 VDC. Since WD9HNU obtained 1.6 VDC his detector chip would seem to have a conversion gain of about 7.16, assuming a 50 Ω load.A calibration control compensates for the detector's allowable gain range.

Using a Digital Meter

I wanted to use a digital voltmeter but found that many of the less-expensive units on the market weren't the easiest fit in this application. Ideally, the meter should have a 2 VDC range, allow the user to place a decimal point wherever desired, and permit the measured voltage to share the same ground as the meter's power supply. The Murata Power Solutions (Datel) DMS-20LCD-1-5-C fits these requirements at a moderate price. Although it has a smallish display, this compact meter draws only 2 mW from the 5-volt supply and mounts with a retaining clip in a 0.80" by 1.30" rectangular hole. Also, its maximum indication of 19.99 (with decimal fixed in the second position) allows up to 20 watts RF input to the wattmeter to be displayed with 10-mW resolution.

WD9HNU's voltage output configuration for the AD633 multiplier chip is also used with the digital meter, but with a small circuit change. Considering the 10-watt full-scale case first, the 0.256 V full-scale output of the multiplier must be raised to 1.000 V in order to give a 10.00-watt indication on the digital meter,with the decimal point fixed in the second position. Dividing 1.000 V by 0.256 V tells us that a voltage gain of around 4 times is needed. This is easily accomplished by scaling (increasing) the AD633's default divided-by-10 voltage output with two

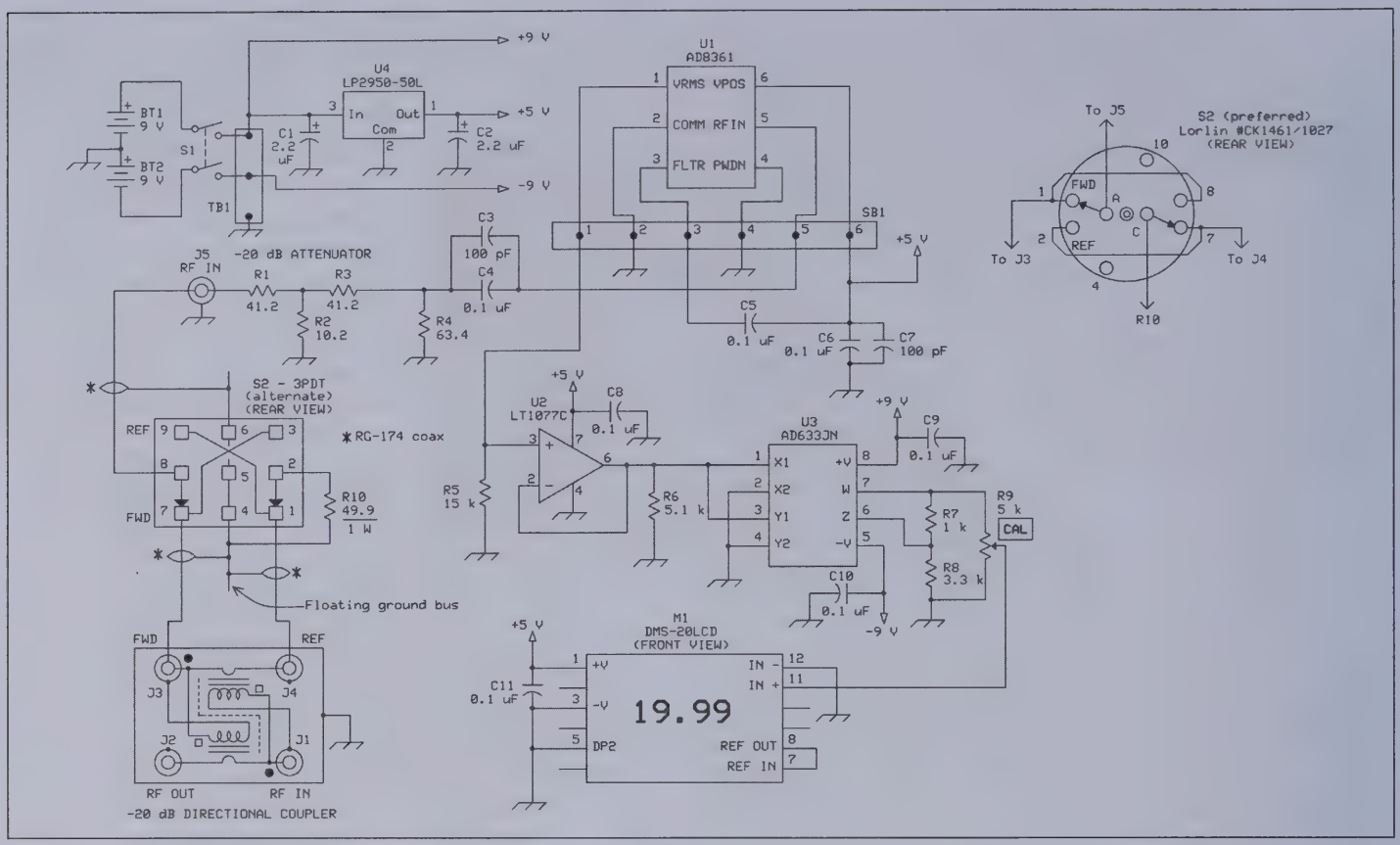


Figure 1—Schematic of the QRP wattmeter.

resistors, labeled R7 and R8 in Figure 1. The scaling factor is calculated by (R7 + R8) / R7. With R7 set at 1 kΩ, a scaling factor around 4.3 results with R8 at 3.3 kΩ. Thus, 0.256 V scaled by 4.3 times will display 11.01 watts, which is too much. Calibration potentiometer R9 adjusts the voltage to set the display to exactly 10.00. At 20 watts RF input the detector's output voltage is nominally 2.26 VDC which, after processing by the AD633 multiplier-would result in 0.512 V at its output, but when scaled and corrected as above we get a display of 19.99 watts.Total current draw due to the resistors is about 1 mA at 20 W input, less at lower powers. Meter overrange is indicated by "1_.__" being displayed (the underlines representblank positions).

Construction Notes

Coupler Box—The coupler box is a Hammond 1411CU aluminum enclosure (3.2" W x 2.2" D x 1.1" H). A diagonal shield is added as shown in Figure 2. The shield is drilled to pass the two RG-8X single-turn transformer links. Clearance holes (about 5/8" diameter) for the BNC RF input/output jacks are made in the rear of the outer enclosure (LMB/Heeger model CR-632) to enable the coupler to be taken out and worked on separately. The low coupler box height allows the 9-volt batteries to be mounted on top with Keystone #79 battery clamps. RG-174 miniature coax cable is used with phono jacks and plugs to make the forward/reflected power output connections to switch S2, and from switch S2 to the circuit board.

T1 and T2—The two 10-turn toroids in the coupler box can easily be wound kink-free with the aid of a crochet hook. These hooks come in many sizes and materials and are widely available where craft supplies are sold. Get a hook that is about half the diameter of the hole in the toroid core. Cut an 18-inch length of #26 magnet wire and stick a small masking tape flag near the starting end. Working away from you, push about four inches of the starting end through the toroid core, then pull it up and back over the top of the core and hold it there. With your free hand, pull the long end of the wire tight and pass it up, over and straight down the other side of the core. Use the crochet hook to reach through the core, hook the wire and pull it smoothly all the way back through the core. Again, pull the wire tight, pass it up, over and down the other side, hook it, pull it through, etc. Space the winding over the majority of the core's circumference and avoid overlapping turns. When the winding is finished twist the free ends together a few times, then go back and verify that the wire passes through the center of the core exactly 10 times.

In the schematic of the coupler box (drawn to reflect the Tandem Match design), the open squares by the toroid windings denote the flagged, or starting end of each winding; the black dots by the single-turn coax links denote the end of each coax braid that is grounded—do not ground the other end of the coax braids! The braids form Faraday shields which block capacitive coupling but allow inductive coupling.

The connections shown in Figure 2 are for toroids wound proceeding to the right from the starting turn; reverse the labeling of J1 and J2 if you wind them proceeding to the left.

Forward/Reflected Power Switch—

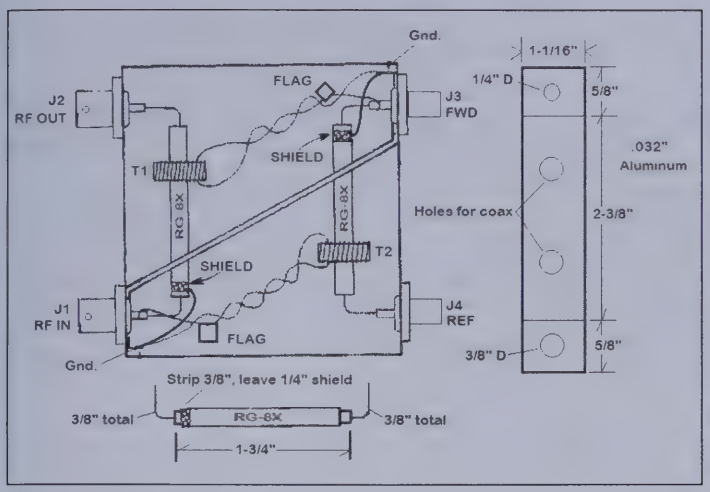


Figure 2—Drawing of the -20 dB coupler box. Jacks are spaced2 inches on center.

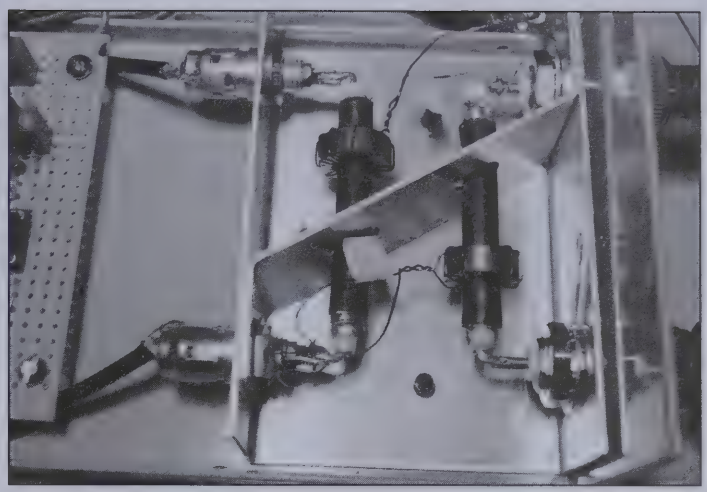


Photo of the completed coupler box, showing howit is installed in the wattmeter case.

The coupler has its outputs switched via 3PDT switch S2 mounted on the front panel. The center pole contacts are tied together and act as a floating ground bus for the coax shield braids and 49.9 Ω resistor (actual ground is via the coax shields to the phono plugs at the coupler box). The switch is cross-wired to reverse the forward and reflected connections when the toggle is thrown, as shown pictorially in the schematic. All wiring to the switch was completed before installing it in the box.

A Lorlin model CK1461 or 1027 miniature rotary switch may have been a better (but more expensive) choice here but poor layout planning on my part prevented its use. The floating ground bus can be installed across pins 4 and 10. Jumpers are needed between pins 1 and 8 and between pins 2 and 7.

In the switch position shown in Figure 1, the forward power output of the coupler is routed to the input attenuator on the wattmeter circuit board while the reflected output is terminated by the 49.9 Ω, 1 W metal-film resistor. The coupler connections are reversed in the opposite switch position. The input path of the wattmeter circuit provides thenecessary 50 Ω termination for the coupler output being measured (note: the closed contacts on most toggle switches are opposite the direction of the handle).

Surfboard®—The only remaining surface-mounted part from WD9HNU's design is the AD8361 power detector chip. This insanely tiny device (about 1/10th of an inch square) is soldered to a model 33206, 6-pin Surfboard (itself only about a half-inch square) which is plugged in to a 6-pin SIP (single in-line package) socket. You will need a soldering iron with a sharply-pointed tip (i.e., less than 1 mm, about 0.03") and either a small amount of 0.31 or 0.5 mm flux-core wire solder, or a solder paste dispenser. A flux pen (or liquid flux), strong magnification, plenty of light and a tweezers will also be needed. Frankly, if you know or can find someone with the equipment and experience for soldering SMD ICs definitely ask for their help! The AD8361 power detector chip is not only near-microscopic in size, it is extremely delicate and it is not cheap to replace should you destroy it in your first attempt (as I did, including vaporizing one of the fragile Surfboard traces). This is not meant to scare you off, but be forewarned—soldering this chip is best done by someone with experience. The website:

https://josepheoff.github.io/posts/howtosolder-13soldersmdic

shows the process in detail, but for a chip much larger than the AD8361.

If you are going to try it yourself, tape the Surfboard down firmly to the center of a cookie sheet and open the chip package over the cookie sheet—if the chip falls to the floor you may never find it. Use a little flux on the Surfboard pads and on the top and bottom sides of the chip pins. A microscopic etched square on a corner of the chip identifies pin 1; if you can't spot it, it is at the corner that is below and to the left of the printed characters on the chip. A helper with a steady hand can use a toothpick to hold the chip down until a leg or two has been soldered; be sparing with the solder to avoid shorts.

My second try succeeded by using a flux pen, pinhead-sized dots of solder paste placed on the Surfboard pads and a needle-sharp soldering iron tip in a 12-watt iron; these itemsadded up to more bucks spent.

Circuit Board— I mounted most circuit components on a half-piece of RadioShack 2760168 general-purpose prototyping board (www.radioshack.com/collections/).Other types of perf boards and even a solderless breadboard may be used since most of the circuit operates at DC levels. Optional (but recommended) 8-pin DIP and 30-pin SIP IC sockets (which can be snapped into 6-pin lengths),and other parts for this project (including toggle switches, BNC jacks, #26 magnet wire and RG-174 coax) are available at All Electronics (www.allelectronics.com). Mouser has all the other parts except the Surfboard, which is available at Digi-key or Newark Electronics.

Figure 3 is a component-side sketch of the RadioShack board layout and wiring, with an "x-ray" view of the PCB pads and bus strips on the solder side.

Meter Mounting—The Murata digital panel meter mounts with the included brass spring clip which does not slip easily over the plastic meter housing. The trick is to first stand the case on end with the meter in its mounting hole and with its face firmly supported on a flat surface. Place the clip over the back of the meter and carefully press down on the middle of the top and bottom sides of the clip with a screw-

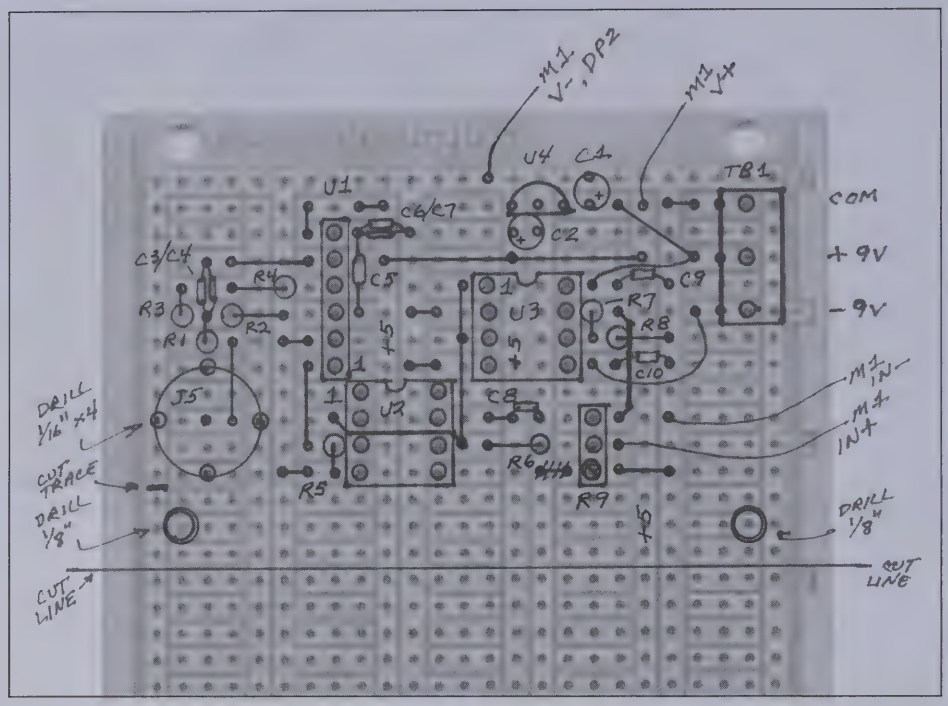


Figure 3—Component-side view of RadioShack PCB with "x-ray" view of solder side. Jumpers J5 to R1 and U2 pin 2 to U2 pin 6 are on solder side. Ream out holes with #54 drill bit where two wires pass through same hole.

driver, alternating a little at a time between top and bottom. The tape label on the top of the meter will probably be scraped away but continue with the screwdriver all around the clip until the meter is held firmly in place. Optionally, Murata offers a plastic bezel for mounting the meter with four tiny screws but the metalworkingfor itrequiresconsiderably more precision.

The meter pins (six on each side) are the square Molex-style and won't fit an IC SIP socket. Get the large SIP sockets offered by Murata (#4320-01074-0). These are PC-style sockets but are easier to use than the housing/crimp-pin style. Murata says to not combine the meter's power-side ground (pins 3 and 5) with the signal-side ground (pin 12); run separate ground leads to the vicinity of the 5-volt regulator's ground point and R8-R9's ground point, respectively. Don't forget to install C11 across pins 1 and 3 of the Molex SIP socket and jumpers between pins 3 and 5, and between pins 7 and 8.

Calibration and Test

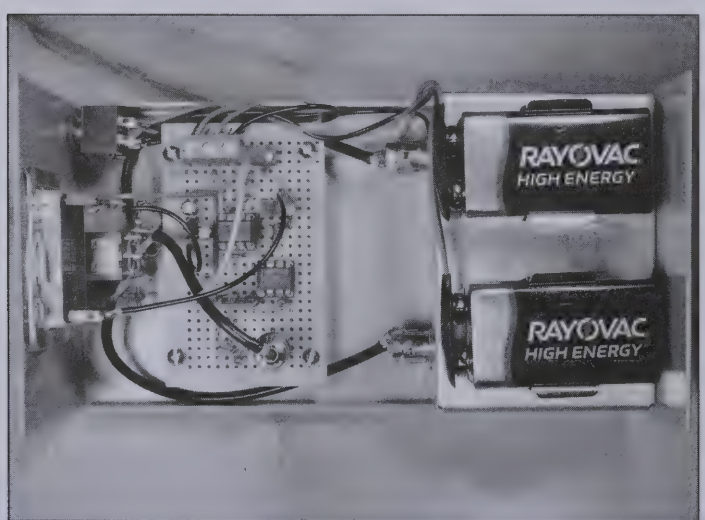
Meter calibration check (optional)—Temporarily disconnect meter "IN +" (pin 11) from the Molex socket. Install batteries and set S1 to the "on" position. Using clip leads, connect an ordinary 1.5-volt dry cell (any size) between the meter's "IN +" and "IN -" pins. Also connect a trusted DMM to these same points. Both meters should display the same voltage digits (plus or minus a few digits; the panels meter's decimal position will be shifted one place to the right). If there is a significant difference, carefully adjust the calibration pot on the back of the panel meter to make the digit display equal (Note: This pot is NOT a zero adjustment—the meter is self-zeroing). Remove the jumpers and reconnect "IN +" to the socket. My meter was within one millivolt of my known-accurate Fluke 177 DMM so no adjustment was required.

Wattmeter Calibration—Connect the QRP wattmeter in series with a wattmeter of known accuracy and a 50Ω dummy load, or measure the RF voltage at the dummy load with a well-calibrated oscilloscope and 10x probe. Apply some RF power and compare wattmeter readings, or usethepeak-to-peak voltage reading from your oscilloscope in this formula to calculate power:

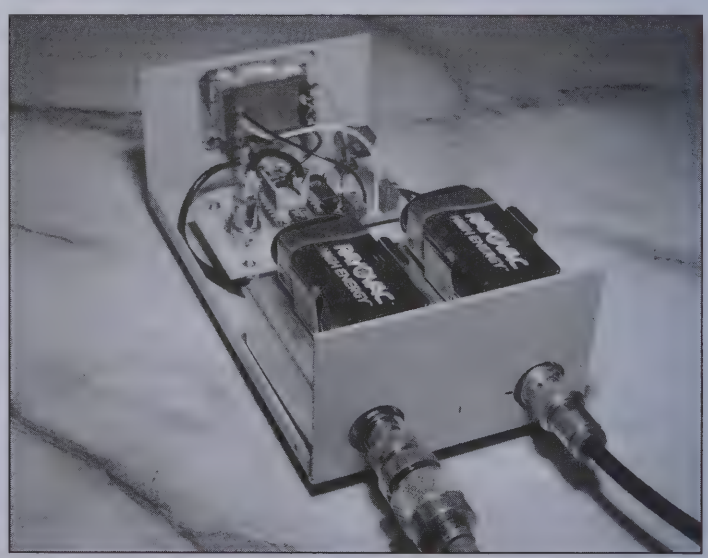
$$W = (0.3535 \times Vp\text{-}p)^2 / 50\Omega.$$

Example:

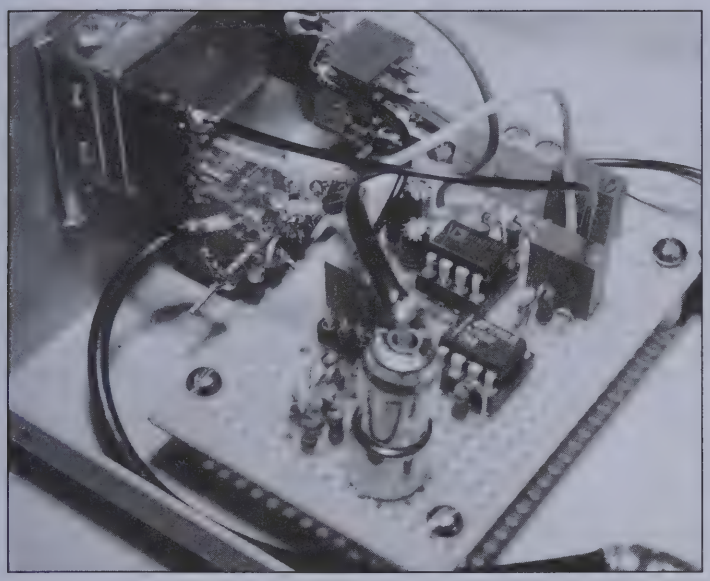
Say your oscilloscope's reading is 31.7 Vp-p across your 50Ω load. Then, $(0.3535 \times 31.7)^2 = 125.6$, and $125.6 / 50 = 2.5$W RF power.



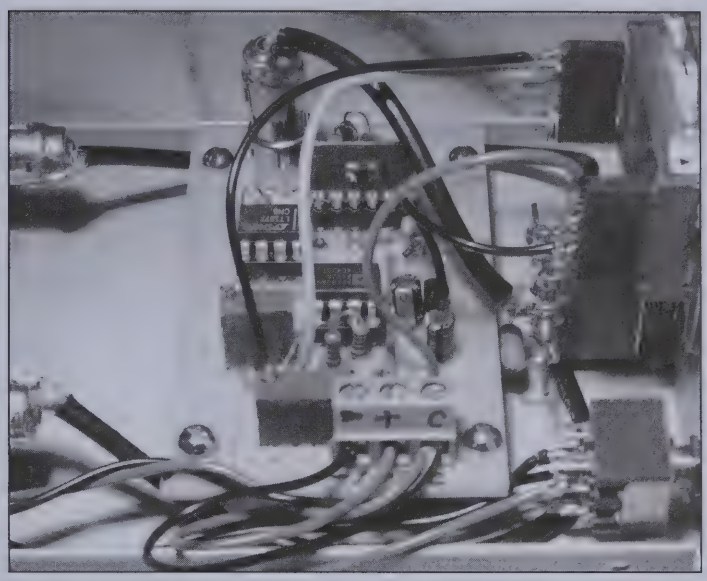
An overall view of the completed wattmeter. The extra potentiometer by TB1 is not used in the final design.



Rear view, showing RF connections.



Left side view.



Rightt side view.

The formula converts the peak-to-peak oscilloscope reading to RMS, squares it, then divides it by 50Ω. If your load isn't exactly 50Ω use the actual value in the formula.

An alternative RF power formula is: $Vp\text{-}p^2 / 8R$, where R is your load resistance in ohms.

Adjust CAL pot R9 on the circuit board (NOT the meter's calibration pot) to make the reading equal to the measured or calculated power. This finishes the wattmeter's calibration.

Calculating SWR

SWR (VSWR) is easily calculated from the wattmeter's forward and reflected power readings. The formula is:

$$SWR = \frac{1 + \sqrt{\frac{P_R}{P_F}}}{1 - \sqrt{\frac{P_R}{P_F}}}$$

The radical portion is just the square root of the reflected power divided by the forward power. Get that number, then divide (1 + that number) by (1 - that number) and use parentheses to insure your calculator will give correct results.

Example:

Say, P_F = 8.2 W and P_R = 0.8 W. The square root of the power ratio, SQRT(0.8 / 8.2), is about 0.31.

Then, (1 + .31) / (1 - .31) = 1.9. The SWR is 1.9:1.

The wattmeter isn't accurate enough to justify using the right-most (least significant) digit in SWR calculations, but that digit can give useful indications when tuning up, etc.

Observations

The wattmeter's response time is very good and it quickly settles at the input power level, enabling you to obtain readings at a glance.You may see some slow drift in the reading due to heating of the transmitter's output transistor(s) and/or the dummy load resistor, when used. The wattmeter tracks the calculated power on the transmission line quite closely based on oscilloscope Vp-p readings (see the formula under "Wattmeter Calibration," above).

Current draw (at 10 W input) is around 12 mA for the positive supply and 4.1 mA for the negative. Curiously, the negative current draw actually drops a little when the meter is reading RF power versus standing by."Power on" status is indicated by digits being displayed on the meter but if you want a lighted indicator, put a high-brightness LED in series with a 47 kΩ resistor across the negative supply. This will add about 160 µA to the draw but may save battery life in the long run. The meter may be turned off while remaining connected to your transmission line.

As in all meters of this type, power readings are most accurate when the RF waveform is a pure sine wave and when the load is a pure 50 Ω resistance.

Lastly, money may be saved by using a less expensive cabinet, switches, BNC jacks, etc. other than those identified in the parts list.

Good luck and happy building!

Notes

- John Grebenkemper, KA3BLO/KI6WX, "The Tandem Match-An Accurate Directional Wattmeter," QST, Jan 1987, pp 18-26
- Coupling factor in dB = $10\log(1/N^2)$ where N = turns per toroid
- The AD8361 currently has a 53-week lead time for back orders (!) and some suppliers have already dropped this part from inventory. Mouser and Digi-Key still have ample stock (May, 2020), but best advice is to order soon.
- RG-8X coax (a.k.a., "Mini-8") evidently comes with outer diameters ranging from about 0.230" to 0.250". The "standard" is nominally 0.242" which provides a snug, sliding fit for FT-50-43 toroids wound with #26 AWG wire.

●●

See the next page for the wattmeter's Parts List

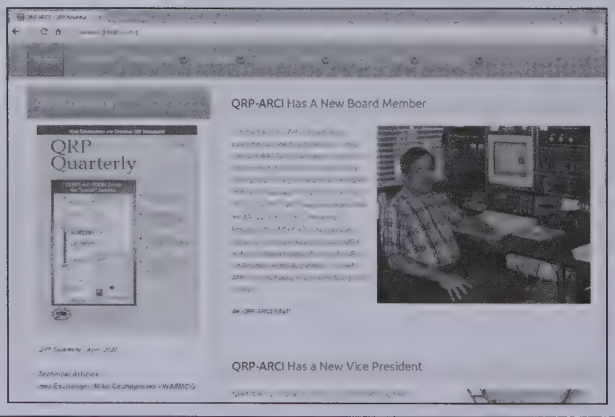
Parts List for K8KK's QRP Wattmeter

M1	DMS-20LCD-1-5-C	1	Murata 2 V digital panel meter
	4320-01074-0	2	Meter connector
U1	AD8361ARTZ-RL7	1	IC - Detector, 6-pin SMD
SB1	33206	1	Surfboard® for U1
U2	LT1077CN8#PBF	1	IC - Op-amp, 8-pin DIP
U3	AD633ANZ	1	IC - Multiplier, 8-pin DIP
U4	LP2950-50LPRE3	1	IC - 5-volt regulator, TO-92
T1, T2	5943000301	2	FT-50-43 toroid core
J1, J2	5227755-2	2	BNC panel jack w/ground lug
J3, J4	3501FPX	2	RCA/phono panel jack
J5	16PJ092-E	1	RCA/phono PCB jack
	3501MX	3	RCA/phono plug
TB1	1729131	1	3-position PCB terminal block
R1, R3	271-41.2-RC	2	1/4-W, 1% metal film resistor
R2	271-10.2-RC	1	"
R4	271-63.4-RC	1	"
R5	271-15K-RC	1	"
R6	271-5.1K-RC	1	"
R7	271-1K-RC	1	"
R8	271-3.3k-RC	1	"
R9	3296W-1-502LF	1	3/8", 5 k Ω potentiometer
R10	CMF6049R900FHEK	1	49.9 Ω, 1-W, 1% metal film
C1, C2	USA1H2R2MDD	2	2.2 µF electrolytic capacitor
C3, C7	C315C101K5GSTA	2	100 pF radial ceramic capacitor
C4, C6, C8, C9, C10, C11	C320C104K5RSTA	6	0.1 µF radial ceramic capacitor
C5	C410C104M5U-TR	1	0.1 µF axial ceramic capacitor
	1226/I-GR	2	9-volt battery snap w/leads
	79	2	9-volt battery clamp
	3479	4	3/8" 4-40 threaded spacer
	CR-632 PAINTED	1	LMB two-tone cabinet
	1411CU	1	Hammond coupler box
S1	M2022SS1W01	1	DPDT toggle switch (power)
S2 (choice)	CK1461 or CK1027	1	4P3T miniature rotary switch
S2 (alternate)	1M31T1B1M1QE-EVX	1	3PDT toggle switch (alt. S2)

PCB—RadioShack #2760168
(www.radioshack.com/collections/)

Misc—
RG-8X coax
RG-174 coax
#26 AWG magnet wire
IC sockets (optional)
#6 x 3/8" sheet metal screws
(3 req'd to mount coupler box)
4-40 x 1/4" bolts (12 req'd)
#4 nuts and lock washers (4 each)
...etc

Note that quantity ten each of the 1/4-W resistors listed costs about the same as a single resistor!



www.qrparci.org

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Ham Radio Frequency Allocations

Aaron Scott—K5ATG

When I first upgraded to my general license and got to look at the HF bands I was intimidated by the number of modes and frequencies that I now had access to. I really did not have an Elmer that could tell me on what frequency I could find certain modes. I was somewhat overly paranoid in worrying that if I used SSB on a frequency where CW was usually at then government black helicopters would come and take me away to some secret prison in some jungle that no one knows exists. So I just started surfing the net, magazines, books etc. looking for the frequencies where I could find the mode that I wanted to operate. I started keeping a list that was broken down into each band. This list does not have every mode that is used on the amateur bands, but I am continuously updating it. I keep it in a binder on my shack desk that also contains a DX Entity list, IOTA List and a list of all US counties broken down by state.

—Aaron Scott, K5ATG

160 Meters (Lower Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
1.800.00-2.000.00	CW		
1.800.00-1.810.00	Digital Modes		
1.805.00	JT65-HF		
1.807.00	PSK31 (USA)		
1.808.00	Olivia 16/1500	1.808.75	750
1.808.50	Olivia 16/1500	1.809.25	750
1.810.00	**CW QRP Calling Frequency**		
1.815.00	**CW QRP Calling Frequency (Australia)**		
1.836.60	WSPR		
1.838.00	WSPR		
1.838.00	JT65-HF		
1.838.00	Olivia 16/1500	1.838.75	750
1.838.20	PSK-31 (Europe)	1.838.15	
1.838.20	WSPR		
1.839.00	JT9		
1.840.00	FT8		
1.843.00	**QRP CW &SSB (Europe)**		
1.843.00-2.000.00	SSB, SSTV, and other wideband modes		
1.910.00	**QRP SSB (Europe)**		
1.995.00-2.000.00	Experimenter		
1.999.00-2.000.00	Beacons		

80 Meters (Lower Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
3.500.00-3.510.00	CW DX Window		
3.522.00	Olivia 16 1500 (East Asia)	3.522.75	750
3.522.00	Olivia 16 1500 (East Asia)	3.523.00	1000
3.530.00	**QRP CW (Australia)**		
3.540.00	**QRP CW (USA)**		
3.560.00	**QRP CW Calling Frequency**		
3.570.00-3.600.00	RTTY Data		
3.572.00	JT9		
3.573.00	FT8		
3.576.00	JT65-HF		
3.577.00	Olivia 16 500	3.775.75	750
3.577.00	Olivia 32 1000 (Region 2)	3.587.00	1000
3.580.00	PSK31	3.580.15	
3.582.00	Olivia 16 500	3.583.25	750
3.585.00-3.600.00	Automatically Controlled Data Stations		
3.590.00	RTTY Data DX		
3.5926.00	WSPR		
3.594.00	WSPR		
3.594.20	WSPR		
3.615.00	Olivia 32 100 (Region 1)	3.616.00	1000
3.615.00	Olivia 32/100 (Australia)	3.623.00	1000
3.690.00	**QRP SSB (Europe)**		
3.710.00	**CW Novice (USA)**		
3.790.00-3.800.00	DX Window		
3.845.00	SSTV (Slow Scan Television)		
3.885.00	AM Calling Frequency		
3.985.00	**QRP SSB Calling Frequency**		

60 Meters (Lower Sideband)

Only one signal at a time permitted on any channel
Maximum effective radiated power is 100 watts PEP

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
5300.5	USB Phone, CW, RTTY and Data		
5346.5	USB Phone, CW, RTTY and Data		
5346.5	**QRP SSB**		
5357.0	USB Phone, CW, RTTY and Data		
5371.5	USB Phone, CW, RTTY and Data		
5403.5	USB Phone, CW, RTTY and Data		

40 Meters (Lower Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
7.003.00	CW (Japan) (Daytime only)		
7.025.50	Olivia 16/500	7.026.25	750
7.028.00	CW (Australia)		
7.030.00	CW (Europe) (USA)		
7.035.00	CW (QRP-L)		
7.0386.00	WSPR		
7.0400.00	WSPR		
7.0402.00	WSPR		
7.040.00	RTTY/ Data DX		
7.060.00	CW (Europe)		
7.074.00	FT8		
7.078.00	JT9		
7.080.00-7.125.00	RTTY/ Data		
7.080.00	PSK31		
7.090.00	**QRP SSB (Europe)**		
7.100.00-7.105.00	Automatically Controlled Data Stations		
7.110.00	CW Novice (USA)		
7.122.00	**QRP CW**		
7.171.00	SSTV		
7.173.00	D-SSTV		
7.285.00	**QRP SSB Calling Frequency**		
7.290.00	AM Calling Frequency		

30 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
10.106.00	QRP CW		
10.116.00	QRP CW		
10.136.00	FT8		
10.130.10-10.140.00	RTTY/Data		
10.138.00	JT65-HF		
10.138.00	JT65-HF		
10.138.50	Olivia 16/500	10.139.25	750
10.138.70	WSPR		
10.139.00	JT65-HF		
10.140.10-10.150.00	Automatically Controlled Data Stations		
10.140.00	JT9		
10.140.10	WSPR		
10.141.50	Olivia 16/500	10.142.25	
10.142.00	PSK31		
10.140.30	WSPR		

20 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
14.060.00	QRP CW Calling Frequency		
14.070.00	PSK-31		
14.073.65	Olivia 16 500	14.074.40	750
14.073.65	Olivia 16/500	14.074.65	750
14.070.00-14.095.00	RTTY/Data		
14.074.00	FT8		
14.075.00	JT65-HF		
14.076.00	JT65-HF		
14.077.65	Olivia 16/500	14.078.40	750
14.078.00	JT9		
14.095.60	WSPR		
14.097.00	WSPR		
14.097.20	WSPR		
14.095.00-14.099.00	Automatically controlled data stations		
14.100.00	IBP/NCDXF Beacons		
14.100.50-14.112.00	Automatically controlled data stations		

20 Meters (continued)

14.105.50	Olivia 32/1000	14.106.50	1000
14.106.50	Olivia 32/1000	14.107.50	1000
14.230.00	SSTV		
14.233.00	D-SSTV		
14.236.00	Digital Voice		
14.208.00	**QRP SSB Calling Frequency**		
14.286.00	AM Calling Frequency		

17 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
18.086.00	**CW (GQRP)**		
18.096.00	**QRP CW**		
18.098.00	JT65-HF		
18.100.00	PSK31		
18.100.00-18.105.00	RTTY/Data		
18.100.00	FT8		
18.102.00	JT65-HF		
18.102.65	Olivia 16/500	18.103.40	750
18.103.65	Olivia 16/500	18.104.40	750
18.104.00	JT9		
18.104.60	WSPR		
18.106.00	**CW (GQRP)**		
18.106.00	JT65-HF		
18.106.00	WSPR		
18.106.00	WSPR		
18.105.00-18/.110.00	Automatically controlled data stations		
18.110.00	IBP/NCDXF Beacons		
18.130.00	**QRP SSB**		
18.162.50	Digital Voice		

15 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
21.060.00	**QRP CW Calling Frequency**		
21.070.00	PSK31		
21.070.00-21.110.00	RTTY Data		
21.076.00	JT65-HF		
21.078.00	JT9		
21.080.00	PSK31		
21.086.50	Olivia 16/500	21.087.25	750
21.087.00	Olivia 16/500	21.087.75	750
21.090.00-21.100.00	Automatically controlled data stations		
21.074.00	FT8		
21.094.60	WSPR		
21.096.00	WSPR		
21.096.00	WSPR		
21.110.00	Novice CW (USA)		
21.150.00	IBP/NCDXF Beacons		
21.285.00	**QRP SSB (Europe)**		
21.340.00	SSTV		
21.385.00	**QRP SSB Calling Frequency**		

12 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
24.900.00	CW		
24.906.00	**QRP CW**		
24.919.00	JT9		
24.920.15	PSK 31		
24.920.00-24.925.00	RTTY Data		
24.951.00	FT8		
24.924.60	WSPR		
24.926.00	WSPR		
24.926.20	WSPR		
24.925.00-24.930.00	Automatically controlled data stations		
24.930.00	IBP/NCDX Beacons		
24.950.00	**QRP SSB**		

10 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
28.060.00	**QRP CW Calling Frequency**		
28.070.00-28.210.00	RTTY/Data		
28.074.00	FT8		
28.078.00	JT9		
28.110.00	Novice CW (USA)		
28.120.00-28.189.00	Automatically controlled data stations		
28.124.60	WSPR		
28.126.00	WSPR		
28.126.20	WSPR		
28.200.00	IBP/NCDXF Beacons		
28.190.00-28.225.00	Beacons		
28.355.00	AM (Japan)		
28.360.00	SSB (Europe)		
28.365.00	**QRP SSB (Europe)**		
28.385.00	**QRP SSB Calling Frequency**		
28.680.00	SSTV		
28.885.00	SSB		
29.000.00-29.200.00	AM		
29.300.00-29.510.00	Satellite Downlinks		
29.520.00-29.580.00	Repeater Inputs		
29.600.00	FM Simplex		
29.620.00-29.680.00	Repeater Outputs		

6 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities	Center MHz	Offset Hz
50.000.00-50.100.00	CW Beacons		
50.096.00	**QRP CW**		
50.060.00-50.080.00	Beacon Subband		
50.100.00-50.300.00	SSB, CW		
50.100.00-50.125.00	DX Window		
50.125.00	SSB Calling Frequency		
50.300.00-50.600.00	All Modes		
50.290.00	PSK31		
50.293.00	WSPR		
50.294.40	WSPR		
50.294.60	WSPR		
50.313.00	FT8		
50.323.00	FT8		
50.600.00-50.800.00	Non voice communications		
50.620.00	Digital (packet) calling		
50.800.00-51.000.00	Radio remote control (20 kHz channels)		
51.000.00-51.100.00	Pacific DX window		
51.120.00-51.480.00	Repeater inputs (19 channels)		
51.120.00-51.180.00	Digital repeater inputs		
51.185.00	**QRP SSB**		
51.500.00-51.600.00	Simplex (6 Channels)		
51.620.00-51.980.00	Repeater outputs (19 channels)		
51.620.00-51.680.00	Digital Repeater Outputs		
52.000.00-52.480.00	Repeater inputs (except as noted; 23 channels)		
52.020.00-52.040.00	FM Simplex		
52.200.00	TEST PAIR (input)		
52.500.00-52.980.00	Repeater Outputs (except as noted; 23 channels)		
52.525.00	Primary FM Simplex		
52.540.00	Secondary Simplex		
52.700.00	TEST PAIR (output)		
53.000.00-53.480.00	Repeater inputs (except as noted; 19 channels)		
53.000.00	Remote base FM Simplex		
53.200.00	Simplex		
53.100.00, 53.200.00, 53.300.00, 53.400.00	Radio remote control		
53.500.00-53.980.00	Repeater outputs (except as noted; 23 channels)		
53.500.00, 53.600.00, 53.700.00, 53.800.00	Radio remote control		

2 Meters (Upper Sideband)

Frequency MHZ	Mode/Activities
144.000.00-144.050.00	EME (CW)
144.050.00-144.200.00	General CW and weak signals
144.060.00	QRP CW
144.100.00-144.200.00	EME and weak signal SSB
144.144.00	PSK 31
144.174.00	FT8
144.200.00	National Calling Frequency
144.200.00-144.275.00	General SSB operation
144.275.00-144.300.00	Propagation beacons
144.285.00	QRP SSB
144.300.00-144.500.00	New OSCAR subband
144.488.50	WSPR
144.489.90	WSPR
144.490.10	WSPR
144.500.00-144.600.00	Linear translator inputs
144.600.00-144.900.00	FM Repeater Inputs
144.900.00-145.100.00	Weak signal and FM Simplex
145.100.00-145.200.00	Linear translator outputs
145.200.00-145.500.00	FM Repeater Outputs
145.500.00-145.800.00	Miscellaneous and experimental modes
145.800.00-146.000.00	OSCAR Subband
146.010.00-146.370.00	Repeater inputs
146.400.00-146.580.00	Simplex
146.520.00	National Simplex Calling Frequency
146.610.00-146.970.00	Repeater Outputs
147.000.00-147.339.00	Repeater Outputs
147.420.00-147.570.00	Simplex
147.600.00-147.990.00	Repeater Inputs

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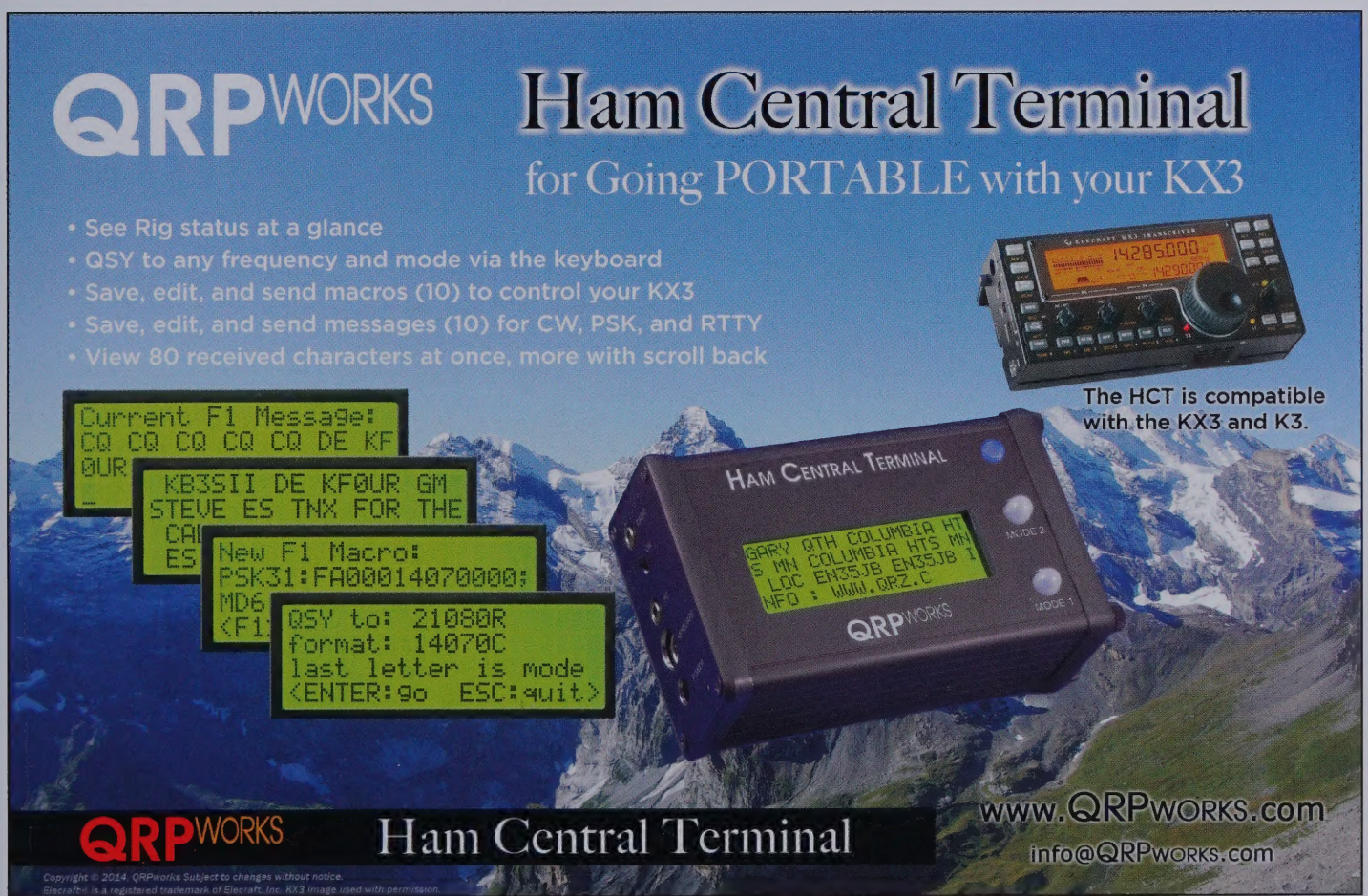
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